MASTER'S THESIS

Postoperative outcomes following revision total knee arthroplasty.

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ABSTRACT

This Masters by Research thesis explores patient outcomes following revision total knee arthroplasty.

I begin by exploring the background of osteoarthritis, the nature and impact of this disease on individuals and the community, and the management options commonly used to address this disease.
I then explore the total knee arthroplasty procedure, followed by the revision total knee arthroplasty procedure and the difficulties commonly encountered. This is followed an overview of current published research on this topic, including the overall understanding of RTKA as a surgical procedure and patient outcomes postoperatively.

The research questions and methodology utilized to develop this research is then detailed.

I then present 4 chapters currently pending submission for publication. These chapters address varied aspects of Revision Total Knee Arthroplasty, including Postoperative outcomes, patient satisfaction, patient perspective and experience, and technical factors which contribute to successful outcomes.

I finish with a discussion regarding RTKA, the current difficulties, and opportunities in the future. Limitations of this research and my personal experience are also included.

This submission ends with an appendix of documentation and research tools used during the project. Statistical workings are also included as an appendix.

KEYWORDS: Revision Total Knee Arthroplasty, RTKA, Long term outcomes, Patient satisfaction.

DECLARATION OF ORIGINALITY

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Master of Science by Research (Health Sciences).

This thesis represents my own original work towards this research degree and contains no material that has previously been submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

Dr Jonathan Quinn

PRESENTATIONS / PUBLICATIONS

Presentations:

Australian Orthopaedic Association Annual Scientific Meeting, 2018. Perth, WA.
Topic – Patient Satisfaction following Revision Total Knee Arthroplasty

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“The lived experience” – a patient perspective of Revision Total Knee Arthroplasty
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A reliable surgical approach to Revision Total Knee Arthroplasty
Submission pending

ETHICS DECLARATION

The research associated with this thesis received ethics approval from the Bond University Human Research Ethics Committee.
BUHREC approval number: 0000015604 ‘Long term outcomes following revision total knee arthroplasty’

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Dr Raymond Randle has provided both the opportunity for this research project, as well as guidance through the clinical aspects of research in orthopaedics. His technical expertise as a surgeon is combined with a passion for orthopaedic research and focuses on providing optimal outcomes for patients. Dr Randle's dedication to providing high quality arthroplasty surgery over many years has enabled the identification of a large patient cohort, which provides the opportunity to contribute a significant body of research to the orthopaedic community. Dr Randle's openness and transparency to data collection is an example of his dedication to patient care. As a member of the orthopaedic community, I aspire to positively impact my patients in a similar way. The patient comments regarding Dr Randle as a surgeon and as a person is testimony to his genuine care for those he treats.

The completion of this research would not be possible without the support of my wife and family. Their ongoing encouragement provides a valuable source of motivation to pursue high quality research, with the goal of improving patient care. Despite the sacrifices necessary to complete research of this calibre, they have always been a source of motivation and without them this degree would not have been achieved.

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ABBREVIATIONS

Revision total knee arthroplasty	RTKA
Total knee arthroplasty	TKA
Australian Orthopaedic Association National Joint Replacement Registry	AOANJRR
High Tibial Osteotomy	HTO
Unicompartmental knee arthroplasty	UKA
Oxford Knee Score	OKS
Range of motion	ROM
Patient Reported Outcome Measures	PROMs
Mahomed Satisfaction Scale	MSS
Periprosthetic Joint Infection	PJI

CHAPTER 1: BACKGROUND

1.1 Summary

Osteoarthritis affects a significant percentage of the population, and is resultant in substantial burden of disease within our society.(1) Osteoarthritis is a degenerative joint disease, affecting 9% of the Australian population.(2) Osteoarthritis is the most common form of chronic arthritis, with radiological evidence present in over 50% of people over 65 years of age.(3) Osteoarthritis is characterised by joint pain and mobility impairment associated with the gradual wearing of cartilage. There is currently no cure for osteoarthritis. Treatment is aimed primarily at symptom relief, improving joint mobility and function, and optimising patient quality of life.(4)

Knee arthroplasty, in its earliest form, was described by Ferguson in 1861.(5) While generally unsuccessful, the idea of knee arthroplasty developed over time, with contributions by many of the forefathers of orthopedics worldwide.

Total knee arthroplasty (TKA) as we know it today is widely accepted as a beneficial treatment modality to address pain and functional limitations associated with osteoarthritis of the knee. Primary total knee replacement in Australia has increased by 130% since 2003. There have been 494,571 primary total knee procedures reported to the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR), including 50,860 in 2015. (6) The incidence and prevalence of TKA is increasing as the provision of medical care becomes more widely available, facilitating the diagnosis and management of osteoarthritis.(6)

While benefits of TKA on patient function and pain are clear, the reality remains that not all TKA procedures provide full resolution of pain and restoration of function for the patient.(7) With an increasing number of TKA procedures being performed, the medical community must engage in the challenge of identifying and managing patients' who have poorer than expected outcomes post operatively.

Revision total knee arthroplasty (RTKA) is the term used for further surgery on a TKA joint, following the first or 'primary' TKA procedure. RTKA may be performed for a number of reasons, known as 'causes of failure' of primary TKA. RTKA is ideally performed following an identified, surgically correctable cause of failure.(8) RTKA should be performed with the

goal of a significant improvement in the patient's functional outcomes and/or minimisation of pain. Current literature suggests that RTKA generally results in poorer clinical outcomes compared to primary TKA.(9-12)

Between 2003 and 2014 in Australia, revision knee replacements increased over 75%.(6) Currently, the revision rate of primary TKA at 10 years is over 5%.(6) In Australia, over 4000 RTKA procedures are performed annually.(13) RTKA constitutes approximately 8% of all knee arthroplasty procedures performed per year, and has remained at a steady number since 2003.(6) Worldwide, the number and rates of total knee arthroplasty has increased over the past two decades. The yearly rates of TKA have increased by more than 100% over this period. The rate of revision TKA surgery is also gradually increasing, and is projected to increase in the future.(14, 15) These trends have important ramifications regarding total knee arthroplasty procedures and increasing numbers of revision total knee arthroplasty.

The Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) (6) continues to contribute to the foundation of knowledge regarding knee arthroplasty surgery, through the reporting of revision rates, implant usage, and recently, patient characteristics. This and other data contributes significantly to understanding of epidemiological aspects of knee replacement surgery and surgeon preferences, and is a valuable addition to current literature.

This research project aims to investigate the postoperative clinical and patient perspective outcomes following RTKA. Patient-centred outcomes including function, pain and overall satisfaction will be collected and analysed. The orthopaedic community requires further research into the likely outcomes following RTKA, to guide appropriate expectations for surgeons and patients. These outcomes may be influenced by patient characteristics, surgical factors, as well as unknown or unidentifiable influences.
Effective medical research will assist patients and clinicians in making well informed decisions for individual patient care. We aim to provide valuable information to individuals and the wider medical community through this research, enabling discussion and appropriate decision making.

1.2 The nature of osteoarthritis

Osteoarthritis is reported to affect approximately 9% of the Australian population, with a mild increase in prevalence according to national health surveys.(2)

The Australian Institute of Health and Welfare reported on data from the Australian Bureau of Statistics from 2001 through to 2015(2), which demonstrated an obvious increase in the prevalence of osteoarthritis as people age. It was reportedly more common in females in all age groups. The prevalence was reported as 7.5 to 8.1% overall, with a higher prevalence in females of 9.0 to 10.2%, compared with 5.6 to 6.1% in males.

Pathophysiology of osteoarthritis

Osteoarthritis is an idiopathic degeneration of articular cartilage, resulting in pain and loss of function. It is a progressive disease, primarily affecting the hands, spine, hips and knees.(16)
Breakdown of articular cartilage joint surfaces results in fibrillation and fissuring of cartilage, subsequently developing into gross ulcerations, and ultimately disappearance of cartilage from the articular surface.
The exposed underlying bone is accompanied by osteophyte formation and thickening of the subchondral surface. The synovial membrane is also involved in the pathophysiology of osteoarthritis, where inflammation is observed. The production of pro-inflammatory cytokines by the synovial membrane is the proposed mechanism for the catabolic process that occurs in the pathological tissue surrounding the affected joints.
The timing of subchondral bone sclerosis in osteoarthritis remains a topic of debate. It is suggested that thickening of subchondral bone may participate in the progression of osteoarthritis, and the importance of this structure to osteoarthritis pathophysiology is an area of ongoing research. The likely underlying mechanism for subchondral bone changes is abnormal osteoblast behavior.(17)

Symptoms

Common symptoms of osteoarthritis include pain, swelling, and decreased motion at the affected joint. Pain associated with osteoarthritis is initially experienced during and

following activity, but as the disease progresses, pain may be felt with all movement and at rest. Symptoms vary between sufferers, as well as between joints involved. Affected joints may affect gross and fine motor function, cause secondary problems with adjacent joints due to poor alignment that ultimately results in difficulty completing the activities of daily living with consequent reduced quality of life in the sufferers of osteoarthritis.(16)

Risk factors

Identified risk factors for osteoarthritis development and/or severity include female gender, malalignment of the joint / limb, previous injury to the joint, obesity, and repetitive joint loading tasks.(18-20) There has been no marked difference in prevalence of osteoarthritis among indigenous groups, rural / remote communities, or people of lower socioeconomic status.(16)

Comorbidities

People with other chronic medical conditions have an increased prevalence of osteoarthritis. Data from the Australian Bureau of Statistics supports an increased prevalence of osteoarthritis in patients with cardiovascular disease, back problems, mental health problems, asthma, diabetes, COPD and cancer.(2)
Due to the increased average age of osteoarthritis sufferers, an increased prevalence of other chronic medical conditions is expected within this patient population. However, prevalence remains increased for some diseases despite age adjustment.(16) The presence of multiple chronic health problems results in poorer quality of life and increased healthcare costs.(21, 22)

Impact on Quality of life / Activities of Daily Living

The effects of osteoarthritis can be significant and affect multiple aspects of the patient's life, including physical, social, emotional, relationships and independence.(23) People with osteoarthritis are more than twice as likely to report their health as poor (7.9%) compared to those without osteoarthritis (3.5%), and are less likely to report their health as excellent, or very good.(2) Self-reported severe pain is 4.3 times more likely in people with osteoarthritis compared to people without osteoarthritis.(2)

Psychological wellbeing

Self-esteem and self-image can be negatively impacted by osteoarthritis, and lead to anxiety, depression, and feelings of helplessness.(24-26) People with osteoarthritis are 5.4 times more likely to report very high levels of psychological distress (17%), compared to people without osteoarthritis (3.2%).(2)

Community impact

In Australia during 2014-15, there were 111,053 hospitalisations with a principle diagnosis of osteoarthritis. The age-standardised hospitalization rate has increased, from 371 per 100,000 population in 2006-06, to 413 per 100,000 population in 2014-15.(2) Female patients have a higher rate of hospitalisations.(2)
Osteoarthritis also affects a person's ability to remain in the workforce. People 15-64 years of age with osteoarthritis are 1.5 times more likely to not be in the workforce than those without osteoarthritis.(2)

1.3 Management of osteoarthritis

The treatment of osteoarthritis of the knee (and other sites) includes the use of both non-pharmacological and pharmacological interventions. Joint replacement surgery is a cost effective intervention for people with severe osteoarthritis who are unresponsive to conservative therapy.(4, 27)

Non-pharmacological, non-surgical management strategies

Weight loss - Obesity is a risk factor for developing osteoarthritis, particularly for females. Overweight and obese people are at higher risk of their osteoarthritis being symptomatic and progressive.(28) This is thought to be related to the increased load placed on weight bearing joints and increased mechanical stress on cartilage.(29-31) Weight loss and strategies to avoid gaining weight are suggested as primary preventive strategies for knee osteoarthritis.(31) For patients with osteoarthritis who are overweight or obese, weight loss is related to an improvement in symptoms of pain and disability, and use of weight control programs are appropriate.(29, 30, 32)

Exercise - Exercise is an important component of management of osteoarthritis as both a preventive strategy and for symptomatic relief.(28) Physical activity improves general physical health; reduces the risk of the development of other chronic disease; facilitates weight control; and may have psychological and social benefits that improve the patient's overall quality of life.(29-31) Particularly in osteoarthritis of the knee, the pain associated with the inflammation leads to the patients undertaking reduced amounts of exercise. This in turn leads to weakness and atrophy of the quadriceps muscles, which in turn contributes to functional disability caused by joint instability. Exercise has the potential to play a key role in reducing clinical features of osteoarthritis.(29) Pain is an important impediment to implementing exercise programs that might help improve joint stability and thus reduce the clinical impact of osteoarthritis. A common strategy to try and reduce the pain associated with land/gravity impacted exercise programs is to use hydrotherapy. Aquatic exercise programs provide the same general benefits as land based exercise programs but with reduced stress on the joints due to buoyancy. Aquatic exercise may be better tolerated for some patients with knee osteoarthritis.(27, 31, 32) Maintaining good general health and joint function in the presence of osteoarthritis is an important component of successful symptomatic management. Anecdotally, the symptomatic improvement experienced by

patients with osteoarthritis after implementation of an appropriate exercise regime can be significant, and may delay or eliminate the need for operative intervention in the future.

Thermotherapy - Thermotherapy involves the application of heat or cold (heat or ice pack, ice massage) to treat symptoms of osteoarthritis.(30, 33) Cold has an effect by reducing swelling and inflammation, numbing pain and blocking nerve impulses and muscle spasms to the joint.(34, 35)

The effect of localized heat therapies for management of osteoarthritis remains controversial. Difference in opinion exists between authors regarding the physiological impact of hyperthermia on articular cartilage and soft tissues, as well as the efficacy of heat treatments for symptomatic management of osteoarthritis.(36-38) Overall, insufficient evidence exists to advocate for or against the use of heat in osteoarthritis management.(39)

TENS - Transcutaneous electrical nerve stimulation (TENS) is a non-invasive therapy with no known side effects.(28) TENS is administered through the stimulation of cutaneous nerve fibres by a device worn and operated by the patient.(34, 35, 40) It is theorised that TENS provides pain relief by inhibiting the transmission of painful stimuli to the spinal cord and brain pain receptors. The type of device, wave form produced by the device (eg. amplitude, rate and width of pulse), and the location in which stimulators are placed, all influence the quality of TENS administered to the patient and are generally adjusted by the clinician depending on the patient's response. Various TENS regimens are used in clinical practice: high frequency (>50 Hz), low frequency (<10 Hz) and burst frequency or hyper-stimulation (high frequency bursts of stimulation using various pulse widths.(28, 35, 40)

Acupuncture - Acupuncture is a therapy administered through the insertion of sterile needles into specifically identified acupuncture points.(28) The therapy is theorised to have an effect on pain through the triggering of endogenous opioid pathways.(35) Acupuncture has few reported serious side effects when administered by an appropriately trained health care provider.(41)

There remains weak or no evidence to support the use of patellar taping, massage therapy, telephone support, magnetic bracelets, laser therapy, or leech therapy for the management of osteoarthritis.(28, 42-44)

Anecdotally, many patients trial or continue in the use of therapies which have little or no scientific evidence of providing benefit in osteoarthritis. It is therefore important for clinicians to be aware of the alternative therapies available within the community, as many patients may be misinformed or unaware regarding the impact of these modalities. Many of these therapies carry minimal risk to the patient, and therefore if symptomatic improvement is achieved, patients may be reluctant to cease their use. Informed discussion regarding management options is therefore vital in optimizing patient care.

Pharmacological management strategies

Paracetamol - Paracetamol is the oral analgesic of choice for management of early osteoarthritis. Paracetamol reduces pain and fever, but has minimal effect on inflammation. Therefore, it is used more often in mild to moderate osteoarthritis. Paracetamol is generally well tolerated with few side effects when used at the recommended dose for up to 12 months. Effectiveness of paracetamol is related to adequate dosage and patients should be encouraged to take medication regularly according to directions to reduce pain episodes.(41, 45-48)

Oral non-steroidal anti-inflammatory drugs (NSAIDs) - NSAIDs are recommended for treatment of acute osteoarthritis pain due to their anti-inflammatory and anti-nociceptive effects. When paracetamol is not sufficient for pain relief, an appropriate traditional NSAID or COX-2 NSAID may be added to the patient's pharmacological regimen.(41, 45, 47)

The potential adverse effects of systemic NSAIDs include cardiovascular, gastrointestinal, renal, hepatic, pulmonary and haematologic complications, and therefore must be considered by the patient, surgeon, and primary care physician. Involvement of subspecialist physicians may be of benefit in some patients, such as those with cardiac or renal disease. In otherwise well patients without concerning medical comorbidities, the co-prescription of a proton pump inhibitor is supported by clinical guidelines and health economic analysis.(42, 43)

Using paracetamol in conjunction with a NSAID may achieve effective pain management with intermittent use and a lower NSAID dose.(45, 46, 48, 49)

Opioids - Opioids have a modest effect in the management of moderate to severe osteoarthritis pain in patients for whom paracetamol and NSAIDs are not sufficient or

appropriate. However, long term efficacy of opioid use has not been shown. Opioid use is associated with a high rate of adverse effects that impact upon patients' quality of life, therefore the modest benefit to be gained from opioid therapy should be considered carefully.(41, 47, 50, 51)

Approximately 20 percent of Australians with osteoarthritis use opioids regularly, and one third of Australian patients with chronic pain use opioid medications regularly(52, 53) Opioid use is associated with constipation, nausea, increased cardiovascular risk, increased fracture risk, and increased all-cause mortality.(54, 55) An increase in the prescription of opioid medications corresponds with the increasing rate of opioid related drug overdose, death, presentations to hospital emergency departments and admission to substance-abuse rehabilitation programs.(56, 57)

The societal costs of opioid abuse within the United States was reported as over $50 billion in 2007, with the trend of increasing use likely to result in greater costs in the future.(58, 59) Similarly, investigation into the impact of opioid use in Australia has demonstrated increased prescription of opioid medications, increased opioid-related hospital admissions, increased opioid accidental poisoning, and increased opioid-related deaths.(53, 60)

The use of opioid medications has significant impacts on the health and wellbeing of individuals and societies. The suitability, prescription and use of these medications should be considered carefully given the potentially devastating consequences.

The cautious use of weak opioids may be appropriate; however, these preparations are less effective than strong opioids with the same adverse effects. Referral of patients who require opioid therapy for review by a pain specialist/clinic may be appropriate.(48)

Intra-articular corticosteroid injection - Intra-articular corticosteroid injection is indicated for short term symptomatic management of arthritis. Corticosteroid is injected into the joint cavity following aspiration of synovial fluid under aseptic technique. This technique allows for an increased concentration of medication at the site of desired action, with a lower risk of systemic side effects.(45-47, 61) Due to possible cartilage damage from repeated intra-articular injections, the number of corticosteroid injections is recommended to be limited to

three times per year for the knee. Intra-articular injections to the same joint are usually administered at no shorter than 3 monthly intervals.(31, 46, 61)

Topical NSAIDs - Topical NSAIDs have both analgesic and anti-inflammatory effect related to suppression of local prostaglandin synthesis.(47) Topical NSAIDs are applied to the skin over the affected joint and absorbed through the tissue, producing an increased concentration of the drug at the local site while minimising systemic administration. The benefit is a reduced risk of side effects and medication interactions compared to oral NSAIDs.(46, 62)

Viscosupplementation (hyaluronan and hylan derivatives) - Viscosupplementation is the administration of synthetic hyaluronic acid or hylan products directly into the joint via intra-articular injection. Hyaluronic acid is a naturally occurring substance in the body that contributes to the elasticity and lubrication of synovium and cartilage within the joints. In patients with osteoarthritis, the concentration and molecular weight of naturally produced hyaluronic acid is reduced, providing a rationale for viscosupplementation.

The aim of viscosupplementation is to relieve pain and improve mobility by restoring the protective functions performed by hyaluronic acid.(31, 41, 46, 63, 64) Various hyaluronic acid products are available, with differences in efficacy between particular products. Products are produced with either low or high molecular weights, which influences the number of injections and amount of medication administered in the viscosupplementation course.(46, 64, 65)

Platelet-rich plasma (PRP) therapies have recently gathered media and public attention as alternatives to current management options for knee osteoarthritis. However, multiple systematic reviews of available evidence advocate for further research prior to its widespread acceptance into osteoarthritis treatment regimens. (66-68)

There is weak or no evidence for the use of stem cell injectables, topical capsaicin, glucosamine hydrochloride and glucosamine sulphate, braces and orthoses, electromagnetic fields, chondroitin sulphate, vitamin / herbal / other dietary therapies, therapeutic ultrasound, or cognitive behavioural therapy in the management of osteoarthritis.(28)

Operative management of knee osteoarthritis

Arthroscopy - Knee arthroscopy has previously been indicated in the management of knee osteoarthritis. Current recommendations describe no beneficial effect of arthroscopic debridement / lavage on the natural history of osteoarthritis. However, the judicious use of knee arthroscopy may be indicated in the management of symptomatic coexisting pathology.(69)

Meniscectomy - Current orthopaedic practice avoids complete meniscectomy for knee pain and osteoarthritis. Previously, surgical management did often include complete meniscectomy for meniscal tear or other symptomatic pathology. Research has since shown an increased risk of osteoarthritis following meniscectomy. (70)

High Tibial Osteotomy- High Tibial Osteotomy (HTO) is a bony realignment procedure of the proximal tibia, which aims to offload either the medial or lateral compartment of a symptomatic arthritis knee joint. This procedure has limited indications, but published literature does support its use in appropriate patients. Short and longer-term outcomes are acceptable in most patients.(71-73)

Unicompartmental Knee Arthroplasty- Unicompartmental knee arthroplasty (UKA) involves replacement of either the medial or lateral components of the tibiofemoral joint.(74) However, due to the partial nature of this procedure and implant, a stringent exclusion criteria is recommended. The standard indications for UKA have been outlined to select patients with single compartment radiographic disease and symptomatology, in patients with low functional demands, low levels of activity, older age, and low body weight.(75)

Knee Arthrodesis- Knee arthrodesis has been performed for more than 100 years and is currently a treatment option for limb salvage in a failed total knee arthroplasty, unilateral post-traumatic osteoarthritis in a young patient, reconstruction after tumor resection, and knee joints that are unable to be reconstructed after severe trauma. (76) Arthrodesis of the knee can provide a stable, painless extremity for high-functioning patients who are able to walk.(77)

1.4 Total Knee Arthroplasty

The goals of operative management of osteoarthritis are to restore joint function, relieve pain and improve quality of life.(16) TKA results in significant improvement in function and pain in over 90 percent of patients.(78) Joint replacement surgery is a cost-effective intervention for people unresponsive to medication alone.(6)

There are over 50,000 primary TKA procedures performed annually in Australia. The rate of TKA continues to increase, with the majority of TKA (97.5%) being performed for osteoarthritis.(6) The age-standardised rate of knee replacement increased by 29% from 133 to 172 per 100,000 population over the 10 years to 2014–15.(16) Primary TKA is more common in females, with a mean age of TKA patients of 68 years. The proportion of patients under 55 years undergoing TKA remains small (6.8%).(6)
Younger people (<55 years) who undergo TKA have a higher rate of revision procedures. Males have a higher rate of revision compared to females. At 15 years, the cumulative percent revision of primary total knee replacement undertaken for osteoarthritis is 7.3%.(6)

The first TKA procedures were considered experimental, with only 50% likelihood of a successful outcome for patients.(79) Since this time, the advancements made in TKA technology and application have been significant, with ongoing research and scrutiny to ensure acceptable outcomes for patients. This has resulted in the improved outcomes of TKA which we see today.
Despite the improvements in TKA, approximately 20 percent of patients remain dissatisfied post operatively.(7) The exact causes of this is still largely unknown, with orthopaedic surgeons suggesting a variety of possible aetiologies.(80)

<u>The History of Total Knee Arthroplasty</u>

The total condylar type of knee arthroplasty currently used was introduced in the 1970's both in the United States of America and abroad.(81)

The first implantation of a hinge knee arthroplasty prosthesis was in the 1890's, credited to Theophilus Gluck.(82) The original design utilised an ivory hinge and plaster of paris for

fixation. This initial implant and technique had a high failure rate due to infection, inadequate fixation, and poor metallurgy.

The 1950's saw the development of the cobalt chrome prosthesis, developed by Dr Walldius.(79, 83-85)
Condylar Knee Replacement involves replacement of the entire tibiofemoral joint surfaces, with components moving independent of each other unlike the hinge design. These implants require smaller bone cuts, and soft tissue balancing is utilised to enhance stability of the joint. (81)

1971 saw the release of the DuoCondylar prosthesis by Dr John Insall and colleagues at the Hospital for Special Surgery.(86) Use of this prosthesis led Insall and colleagues to develop the Total Condylar (TC) Knee prosthesis, designed to increase stability through Posterior Cruciate Ligament retention, whilst also resurfacing the patella articular surface. The TC knee prosthesis was release in 1974, and became the first widely utilised total knee arthroplasty prosthesis.(86-88) The TC 3 prosthesis was released in 1976, designed with improved constraint to allow for knee replacement in patients with increased deformity and instability.(86) The Posterior Stabilised knee prosthesis was developed in 1978 by Insall and colleagues, to further address deficiencies with knee arthroplasty designs.(89, 90)
The Press-Fit Condylar (PFC) knee prosthesis was developed in 1985 and modified in 1989, allowing for use of posterior stabilised and constrained knee prostheses.(87)

Prosthesis fixation initially required cementing of the prosthesis into the surrounding bone. The first porous-coated, non-cemented implants were used in 1978. Today, a combination of cemented and uncemented implant options are used.(91, 92)

<u>Total Knee Arthroplasty technique</u> (93)

Total Knee arthroplasty is indicated for osteoarthritis, rheumatoid arthritis, and post-traumatic arthritis of the knee. It requires an absence of active infection within the knee joint, appropriate surrounding soft tissue structures to enable stability and mobility of the joint, and is best performed when conservative management options have failed.

Pre-operatively, an appropriate history, physical examination, imaging, and anaesthetic review are required.
An appropriately anaesthetised patient is placed supine on the operative table, with a tourniquet applied proximally on the limb. Intravenous antibiotics are administered at the commencement of the operation, and appropriate sterile prep and drape is performed.
A medial parapatella approach and arthrotomy is most commonly used to allow for adequate exposure and resection.

Resection of intra-articular soft tissues, bony osteophytes, and articulating bony surfaces is performed. The use of cutting guides or other methods of standardised resection allows for the formation of appropriate bone surfaces for implantation of the prosthesis. Trial components are inserted and biomechanics of the joint is assessed. Further bone cuts or soft tissue release can be performed to optimise stability and range of motion.
Copious wash of surgical wound and bone surfaces is performed. Implantation of definitive prostheses then occurs, using cemented or cementless technique based on surgeon preference.
Closure of the surgical wound occurs in layers, with attention to haemostasis. Sterile surgical dressing is applied.

Post-operative care involves assessment of the patient, including comfort and neurovascular status of the limb. Appropriate antibiotics are administered and appropriate venous thromboembolism prophylaxis is prescribed. Most patients are mobilised with assistance beginning on post-operative day 1.

<u>Decision to TKA</u>

The decision to proceed to TKA surgery should follow prolonged conservative management and detailed discussion between the treating surgeon and patient.

There is currently no standardised scoring system or method of determining the appropriate patients or timing of TKA surgery. However, the accepted indications for TKA include:

- Severe knee pain or stiffness which limits activities of daily living, such as walking, climbing stairs, or mobilising out of chairs

- Moderate or severe pain while resting
- Chronic inflammation and swelling which remains despite rest and pharmacological management
- Deformity of the knee
- Failure of symptomatic improvement despite adequate conservative management (94)

More than 90% of people who have had total knee replacement experience an improvement in knee pain and function.(78)

Complications of TKA

The complication rate following total knee replacement is low, with serious complications occurring in fewer than 2% of patients.(94) Despite the low likelihood of complications, these risks must be known and understood by the patients in order to provide informed consent, and it is often during the preoperative consent process that risks are discussed. Chronic illnesses may increase the potential for complications. Although uncommon, when these complications occur, they can prolong or limit full recovery.(94)

The specific risks relevant to TKA include:

Anaesthetic - Anaesthetic risks include: atelectasis, chest infection, heart and lung complications, heart attack, stroke, and death.(95) Anaesthetic risks should be discussed with the treating anaesthetic team during pre-operative assessment and prior to surgery.

Infection - Periprosthetic infection may occur during inpatient stay or after discharge. It can be associated with surgical wound infection, adjacent infection, or haematogenous spread of infection.(94) Surgical site infections are often treated with antibiotics alone, whilst infections involving the prosthesis often require removal and re-implantation of the prosthesis.(94)
Prophylactic antibiotics for infection prevention in TKA is supported in current Australian guidelines. Primary TKA patients receive Cephazolin IV at time of induction or anaesthesia, and 3 further doses over 24 hours postoperatively. Patients with a high risk of MRSA receive Vancomycin IV. Patients undergoing revision TKA receive Vancomycin

IV. Following post-operative antibiotic administration, further antibiotic administration is not indicated unless infection is confirmed or suspected.(96)

Venous Thromboembolism (VTE) - Thromboembolic mortality and symptoms are an important and controversial consideration because they are potentially amenable to risk reduction.(94, 97)

General Considerations - for all patients independent of risk assessment:

- Early mobilisation postoperatively
- Spinal anaesthesia if appropriate
- Use / non-use of tourniquet in TKA
- Signing an informed consent for the agreed and preferred treatment option
- The Minimum treatment for VTE prophylaxis should be three to six weeks, however there is variation in duration recommendations reported between individuals and organisations.

Depending on the patient's risk of VTE postoperatively, a combination of mechanical and/or chemical prophylaxis may be utilised. The specific prophylaxis method instituted is decided by the treating surgeon, with consideration of institutional and regional guidelines. The Australian Arthroplasty Society guidelines for VTE prophylaxis are most commonly adopted within Australia, as these are supported by the Australian Orthopaedic Association and based upon robust scientific review of available literature.(97)

Options for mechanical prophylaxis include: sequential compression device and early mobilisation. Options for chemical prophylaxis include: aspirin, clexane, warfarin and NOACs (non-vitamin k antagonist oral anticoagulants).(97)

Post-operative pain - Pain following TKA surgery is managed by the treating surgeon and surgical team. World Health Organisation guidelines of analgesia and pain management give guidance to surgeons regarding appropriate analgesia administration postoperatively.(98) The vast majority of patients experience excellent pain relief following knee replacement.(94)

Implant problems / Stiffness / Instability - Despite advances in implant designs, materials and techniques, intra-operative and post-operative complications can occur due to implant failure. This may necessitate changes to the intraoperative plan, use of implants with increased stability, or postoperative intervention.(94)
Stiffness and decreased motion may occur due to scarring of the knee joint capsule or other surrounding soft tissues, and is more common in patients with poor motion preoperatively.(94)
Instability is a potential postoperative complication, and is a common reason for revision.(6) The intraoperative management of instability is difficult and may require the use of an increased constraint prosthesis or adjuncts to routine knee arthroplasty technique.

Younger patients - Younger patients (<55 years of age) have a higher rate of revision surgery, likely due to increased physical activity and higher demands placed on the prosthesis. The rate of revision for this age group is 10.9% at 10 years postoperatively, and 15.7% at 15 years postoperatively. Men have a higher rate of revision in this patient population.(6)

Expected increase in Primary and Revision TKA

The number and rates of primary TKA has increased by over 100% during the past 2 decades.(6) Joint replacements are subject to mechanical wear and other causes of failure, so some patients will require revision surgery.(16) Survival of Primary TKA at 10 years post implantation is 94%.(6)

Revision knee replacements are re-operations of previous knee replacements where one or more of the prosthetic components are replaced, removed, or one or more components are added.(6) Revision surgery may be required to address complications such as infection, loosening of prosthesis, fracture, dislocation, stiffness, and failure of prosthesis.(95)

RTKA is increasing in frequency in association with increasing TKA and other knee arthroplasty procedures.(6) The incidence of RTKA in Australia is 8% of all knee arthroplasty procedures.(6)

A large increase in the volume of arthroplasties is expected using a conservative projection model that accounts for past surgical trends and future population changes in Australia.(99) The rate of revision TKA surgery is also gradually increasing, and is projected to increase in the future. These trends have important ramifications regarding total knee arthroplasty procedures and increasing numbers of revision total knee arthroplasty.(6, 14)

1.5 Revision Total Knee Arthroplasty

Poor post-operative outcome or post-operative complication prompts consideration of revision total knee arthroplasty (RTKA) as an option to attempt restoration of function and resolution of pain. RTKA is performed to surgically address one or more causes of failure of the primary TKA. A multitude of ‘causes of failure’ have been identified by the orthopaedic community, the most common being loosening / lysis, infection, patellofemoral pain, pain, and instability.(100, 101)
Importantly, in some circumstances, patients may be dissatisfied without an identifiable cause of failure. These patients warrant careful consideration in a multidisciplinary fashion to ensure the appropriate provision of care.

The Australian Orthopaedic Association National Joint Replacement Registry reports the rate of RTKA increasing with time from primary TKA operation. The cumulative rate of revision of primary TKA is 1.0% at 1 year post-operatively, 3.6% at 5 years post-operatively, 5.3% at 10 years post-operatively, and 7.3% at 15 years post-operatively. Younger patients and men have a higher rate of revision at all time points assessed.(6)

<u>Challenges of RTKA</u>

The challenges of revision TKA are varied and significant.(102) They include:

Infection - Eradication of infection is required to enable pain free motion of the prosthetic joint. The effects of infection on the patient and the prosthetic joint result in continual worsening of clinical condition unless successful eradication of infection is achieved.(102) Periprosthetic joint infections are initiated by introduction of microorganisms at time of

surgery, contiguous spread from adjacent site such as surgical wounds, or haematogenous spread from a distant site.(103)

Biofilms are complex communities of microorganisms embedded in an extracellular matrix that forms on surfaces. Mature biofilms have a multicellular nonhomogeneous structure in which their component microbial cells may communicate with one another, and different subpopulations may have different functions, together supporting the whole biofilm and rendering biofilms somewhat analogous to a multicellular organism.(103) In the biofilm state, bacteria are protected from antimicrobials and the host immune system, making treatment of infection difficult without a biofilm-directed treatment strategy, which today mandates surgical intervention, in many cases including prosthesis removal, to achieve a cure.(104)
The reduced antimicrobial susceptibility of bacteria in biofilms is related to their low growth rate, the presence of resistant bacterial subpopulations, and a microenvironment within the biofilm that impairs antimicrobial activity.(105, 106) Due to the formation of biofilm and highly resistant organisms, established periprosthetic infection is difficult to eradicate.(103) Infection can propagate from the joint space to surrounding soft tissues and bone. Prolonged infection ultimately results in involvement of the entire metaphysis and adjacent diaphysis of the affected bone.(103) This results in resorption of bone at the bone-prosthesis interface, soft tissue swelling, lysis and premature loosening of the component.(107)

Periprosthetic infection thus results in the clinical situation often involving pain, instability, bone resorption and loosening of the prosthesis, difficulty in eradication of infection, and a source of infection that may result in an acute patient deterioration due to septicaemia.

Fixation - Bone defects are often present in revision TKA. This bone loss may be greater than expected, and results in difficulty for revision implant fixation and appropriate restoration of the articulating joint line.(102) Treatment of bone loss can be managed through bone allograft, prosthetic augments or the use of cement fixation.(108, 109) Cement fixation often results in further bone resorption, which may become symptomatic and increase difficulty with further revision operations.(102, 110) The ideal attributes of revision prostheses, including stem length, thickness and surface remain unanswered.(110)

Morgan-Jones et al described the importance of ‘zonal fixation’ in the RTKA setting, by considering and optimising fixation of the revision implants into the epiphyseal, metaphyseal, and diaphyseal regions.(108)
A number of methods for obtaining fixation within these adjacent regions can be utilised, with selection being suited to individual patient and implant factors. The most commonly used techniques to obtain fixation include bone graft to defects, cemented implants, artificial augments, metaphyseal cones, and diaphyseal stems.

The importance of metaphyseal cementation in RTKA tibial implants is supported by Sanz-Ruiz et al, who describe increased radiolucency surrounding tibial components following superficial cementation in comparison to metaphyseal cementation. These authors found no clinical difference between groups at the time of follow up.(111)

Classification of bone loss during RTKA is commonly described using the Anderson Orthopaedic Research Institute classification system, first described by Engh et al in 1998.(112)This system divides bone defects into anatomic location (femur or tibia) and condition of metaphyseal segment (intact, damaged, deficient).

Ligament instability - Equal joint space gaps during flexion and extension result in a well-balanced knee, which is an important consideration for stability and range of motion postoperatively. If poor ligament balancing is present following appropriate implant positioning, a combination of soft tissue procedures and implant selection can be utilised to improve stability. Increasing constraint of the implant may lead to increased loosening due to stress transmission to the implant interface, and so should be avoided where possible. However, at times, stability can only be achieved with increased implant constraint.(102)

Decision to RTKA

There remains a paucity of literature regarding the long term outcome of RTKA. This is likely due to the relatively low numbers of RTKA performed and the more recent nature of RTKA as a treatment modality. The increasing need for this surgery is testament to the prolonged survival of patients who have undergone their primary TKA and reaching the

age when prosthesis failure is an expected outcome. The published literature demonstrates that RTKA generally results in poorer clinical outcomes when compared to primary TKA.(11, 113) These outcomes include higher re-infection rates, lower patient satisfaction, lower functional ability, increased levels of pain, and increased rates of further operative intervention. Outcomes are generally found to be poorest in RTKA for infection.(9, 114-119)

The undertaking of revision TKA surgery should be discussed appropriately and likely outcomes considered by both the patient and surgeon. There is currently no widely used scoring system or clear indications for RTKA surgery. Instead, each clinical situation is managed by the treating surgeon and orthopaedic colleagues on a case by case basis. The postoperative condition is not universally better than preoperatively, and the impact of a negative outcome on a patient postoperatively is not to be underestimated.
The decision to undertake RTKA surgery should be substantiated by high quality research, informed consent, and a thorough understanding of possible postoperative outcomes by both the patient and surgeon.

CHAPTER 2: LITERATURE REVIEW

A structured literature search was conducted to identify published results of survivorship and functional outcomes following RTKA procedures.
The literature review sought to identify the postoperative outcomes of patients following RTKA, as well as factors which contributed to these outcomes. This included the preoperative and postoperative functional, clinical, and patient reported outcomes. We also sought to identify from previous publications if any specific patient subpopulations were at risk of poor outcomes.

We predicted a small number of relevant publications at the completion of our literature search, due to the comparatively low number of RTKA procedures performed. We also acknowledge the relatively low number of RTKA procedures performed by individual surgeons or at a single institution per year, which results in small cohorts for single surgeon or single institution publications.

The Literature search was conducted using a structured search strategy, based on the PRISMA guidelines. (120, 121) While a formal systematic review was not the goal, the methods were chosen according to these recommendations to ensure a broad capture of relevant literature and high quality methodology to review identified resources.

Online medical databases were searched over the initial study period (January 2016 to April 2017) with regular updates to search results.
The databases used were Pubmed, Medline and Science Direct. These were chosen based on previous experience of primary investigator and recommendations from senior colleagues.
The search terms used to identify relevant studies were: “RTKA” OR “Revision TKA” OR “Revision total knee replacement” OR “Revision total knee arthroplasty”.
Pubmed database yielded 479 results, Medline yielded 834 results, ScienceDirect yielded 269 results. This resulted in a total of 1582 results. Other sources of published literature were also searched to expand the literature search. These sources included Google Scholar, references of previously identified studies of relevance, and relevant orthopaedic journals. A total of 1601 records were found.

After removal of duplicate publications, a total of 818 records were screened for relevance to our research questions. Based on title and abstract, 718 records were removed from the search at this stage. The removal of studies at this stage was based on irrelevance to our research question and goals. The broad search strategy sought to identify all published literature on revision total knee arthroplasty, which included many studies that were unrelated to postoperative outcome or patient satisfaction. Articles unavailable in English language, single case studies, single surgeon editorials and commentaries were also removed at this stage.

The remaining 100 records were obtained in full text versions, and evaluated for contribution to our research questions. 59 records were then removed from our search, resulting in 41 records deemed appropriate to our literature review. These publications were selected based on relevance and applicability to our research questions and patient population. The 59 publications removed at this stage were due to specifics of content, such as the use of specific operative techniques not utilised in our patient cohort, non-clinical studies, or studies investigating other aspects of clinical care.

No quantitative analysis was conducted in this research project.

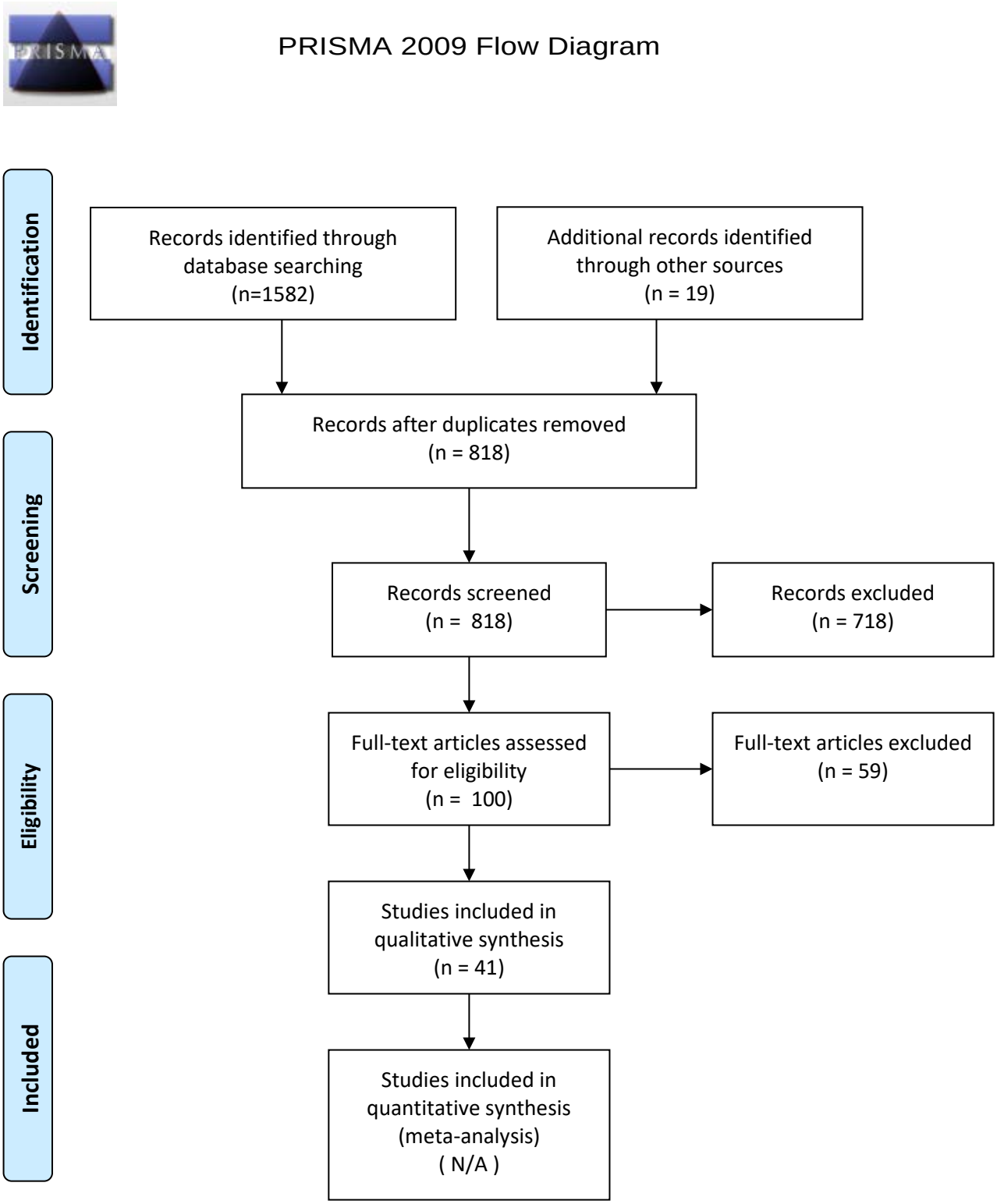

Figure 1 – PRISMA literature search diagram

2.1 Methods of outcome measurement

The efficacy of TKA has remained under close scrutiny, with the development of a number of rating or scoring systems. Whilst clinicians often prefer quantitative measurements of outcomes, “there is a growing recognition that evaluation should use patient-reported outcome tools and assessments of satisfaction”.(122)
Patient-reported outcome measures (PROMs) are increasingly being used to assess functional outcome and patient satisfaction. They provide a framework for comparisons between surgical units, surgical techniques, and individual surgeons. (123)

The introduction of PROMs reflects a universal growing recognition that the patient’s perspective is important in efforts to improve the quality and effectiveness of health care.(124) The integration of PROMs during preoperative and postoperative assessment as standard practice in surgical departments in the NHS was introduced in 2009, and has solidified the use and value of these outcomes in evaluating care provision.(124) Overall, PROMs have become widely used and valued by clinicians, giving surgeons a better understanding of the impact of surgery on patient outcomes.(125) Patient-reported outcome data are important to clinicians and other members of the healthcare team as feedback on the care they have provided. (124)

Oxford Knee Score - The Oxford Knee Score (OKS) was developed by Dawson and colleagues in 1998.(126) It has since been widely used in the pre- and post-operative assessment of TKA.(127)

The OKS is a brief, patient-completed, qualitative assessment tool, used for patients pre or post TKA. It reflects the patient’s assessment of their knee-related health status. The 12 item questionnaire assesses both pain and function with activities of daily living (mobility, standing after sitting, housework, shopping). Each item is followed by 5 responses ranging from no dysfunction/pain to extreme dysfunction/pain.
The OKS involves minimal respondent burden, as it requires an estimated 5-10 minutes to complete. No training or assistance is necessary to complete the questionnaire. The OKS has demonstrated adequate internal consistency and test-retest reliability, and shows good correlation with knee-specific and general health questionnaires. The OKS is

reliable, valid and responsive to change following TKA, and therefore is considered to be a useful clinical tool.(128-130)
The final score determined ranges from 0 to 48, with a higher score demonstrating better function and pain outcomes. A score of 0 is the worst possible outcomes, demonstrating severe symptoms and pain. The minimal clinically important difference in OKS after TKA is 5 points.(131) The OKS has been validated for knee arthroplasty, is used in national arthroplasty registries (England & Wales, New Zealand), and is available in 19 languages.(132)

Mahomed Satisfaction Scale - The Mahomed Satisfaction Scale (MSS) was developed in 2011 specifically to assess patient reported satisfaction following total joint arthroplasty.(133) It is also known as the 'self-administered patient satisfaction scale'. This scale was designed to focus on patient satisfaction by enquiring specifically of pain relief, ability to complete home / yard work, ability to complete recreational activities, and overall satisfaction. It is considered a valid, consistent and reliable instrument for measuring patient satisfaction following knee arthroplasty.(133, 134)
The MSS reports patient satisfaction with a score ranging from 25 to 100. It is calculated by the mean of 4 individual questions assessing aspects of function / satisfaction (overall satisfaction, improvement in pain, improvement in ability to complete home or yard work, improvement in ability to complete recreational activities), each with 4 options ranging from very dissatisfied (25 points) to very satisfied (100 points). An overall score of 100 suggests that the patient is very satisfied in all domains, while a score of 25 suggests dissatisfaction in all domains. In the initial study validating the MSS, the mean 1-year satisfaction score was 84.2 (range 25-100, SD 19). This was in a cohort of primary TKA patients. No definitive cut-off score to differentiate between a satisfied and dissatisfied patient was given by the authors.

Knee Society Knee Score - The Knee Society Knee Score was first published in 1989, and has been widely used since. Its value lies in the ability to differentiate the results of the TKA procedure from the patient's overall level of function and wellbeing.(135) The original Knee Society Knee Score has been updated in 2011, adapted to assess contemporary patient outcomes.(135) This score was not chosen for inclusion in this research due to the requirement for clinical examination to complete the assessment.
There are a number of other scoring systems used to assess outcomes following knee

arthroplasty. Despite ongoing investigations, no single scoring system has been widely accepted to be superior.

2.2 Revision TKA (RTKA)

The published literature on revision surgery is limited, with determinants of functional outcomes after revision surgery being poorly understood.(136) However, it is widely accepted amongst authors that revision RTKA surgery is significantly more challenging than primary TKA.(9, 10) It is also widely accepted that results of revision TKA are generally poorer than primary TKA.(9-12)
The reasons for increased difficulty of surgery and poorer outcomes has been attributed to difficult surgical exposure, stiffness, adhesion of tissues, instability due to ligamentous laxity and poor bone stock.(10) The revision procedure “imparts an additional burden of disability” onto patients, and accordingly “most revision patients will never experience an outcome as favorable as their primary procedure”.(11)

While the outcomes following primary TKA have been well documented and published, the long term outcomes of RTKA are less robustly supported by the literature. RTKA has been shown to result in considerable improvement in outcomes in comparison to the pre-RTKA function.(114) However, as expected, the literature clearly states that overall, post RTKA outcomes are not as good as post primary TKA.(11, 113) The range of motion following RTKA has been demonstrated to be less than following primary TKA.(137)

Following RTKA surgery, the level of improvement in all outcome measures shows significant increase within the first year.(136, 138) This improvement is most dramatic within the first 6 months.(136) From 1 year onwards, the outcome measures plateau, or may decrease slightly. (136, 138) This trend is similar to that of primary TKA, with outcomes peaking at 1 year postoperatively.(136)
The percentage of TKA and RTKAs which fail increases with time, with primary TKA revision rates of 1.0% at 1 year, 3.8% at 5 years, and 5.6% at 10 years postoperatively.(101, 122) In comparison, RTKA failure rates are significantly higher, with re-revision rates of 16% at 5 years and 23.8% at 10 years post RTKA, excluding patients who had initial RTKA for infection.(100)

Patient-perceived outcomes have been reported as the same for primary TKA as RTKA in some studies(10), whilst others report greater satisfaction with primary TKA.(11) There remains a paucity of published research assessing the patient's perspective and satisfaction of RTKA surgery. There is no current standard method of assessing patient satisfaction or patient perspective following arthroplasty surgery.

Risk factors for poor outcome

Studies have identified patient risk factors for a poorer outcome following TKA and RTKA. As expected, patients with a higher number of comorbidities reported significantly worse outcomes following RTKA.(136) Other risk factors identified for a poor functional outcome following RTKA include very high Body Mass Index (BMI), female gender, smoking, and older age, resulting in increased dependence on walking aids at 2 and 5 year follow up (122, 139, 140) It has also been found that knee range of motion (ROM) pre-RTKA was the most significant predictor of post-RTKA range of motion.(137) This is attributed to the difference in soft tissue envelope, and difficulty in obtaining ideal position and function of surrounding soft tissues.

Current international literature suggests the overall complication rate for RTKA to be up to 26.3%, with 12.9% of RTKA requiring re-revision.(114) The mean time to revision is 2.3 years.(141) The rate of re-revision of RTKA in Australia, according to the AOA NJRR, is 16% at 5 years and 23.8% at 10 years post RTKA, excluding patients who had initial RTKA for infection.(100)

Methods of failure

The commonly reported methods of failure of primary TKA in Australia are loosening (25.95), infection (22.5%), patellofemoral pain (10.9%), pain (8.6%), and instability (7.3%).(6) Infection is reported as the most common cause of failure from date of operation until 4 to 5 years post-operatively, at which point loosening becomes the most common cause of failure.(6)

International studies are in line with these findings, and have also demonstrated a high rate of revision for mechanical wear / component failure and malalignment.(80, 113, 142,

143) The literature on RTKA has begun to explore the effect of method of failure of primary TKA on outcomes post RTKA. The literature suggests that the cause of index failure has no significant influence on any outcome measures, apart from significantly increased rates of infection following RTKA for infection.(9)

2.3 Infection and RTKA

TKA complicated by postoperative infection is considered “the greatest challenge to a surgeon performing revision arthroplasty”.(115) The management of periprosthetic TKA infection has been widely investigated. The 2-stage re-implantation procedure combined with parenteral antibiotic therapy has been shown to be the most effective method in the eradication and control of infection, while antibiotic therapy alone is deemed inadequate.(116, 144, 145)

Periprosthetic joint infection (PJI) represents a significant challenge for orthopaedic surgeons, patients, and the community. With the increasing demand for joint arthroplasty, the annual cost of PJI in the united states is estimated to exceed $1.62 billion by 2020.(146)

Risk factors for PJI include: previous operation on the index joint, previous arthroplasty at a different site, American Society of Anesthesiologists’ grade 2,3 or 4, body mass index >25, malignancy, procedure duration >4 hours, bilateral arthroplasty, allogenic transfusion, postoperative atrial fibrillation, myocardial infarction, congestive heart failure, urinary tract infection, chronic pulmonary disease, pulmonary circulation disorders, preoperative anemia, diabetes, depression, renal disease, rheumatologic disease, psychoses, metastatic tumor, peripheral vascular disease, valvular disease, and prolonged hospitalization.(147-149)

Anecdotally, most patients with significant osteoarthritis have comorbid disease, resulting in a large proportion of arthroplasty patients demonstrating PJI risk factors.

The timing and clinical features of PJI can vary widely. PJI is divided based on time since surgery, with early (<3 months), delayed (3-24 months), or late disease (>24

months).(149)

Early and delayed PJIs are likely to have been acquired intra- or peri-operatively, whereas late infection in usually haematogenous in origin.(149, 150) A postoperative superficial surgical site infection may be indicative of deeper infection involving the implant.(150) Early infections may present with systemic or localized signs of infection, such as a persistently leaking wound or the acute onset of fever, pain, swelling, effusion and erythema at the implant site. Untreated infections may form chronic sinuses. Bacteraemia and a systemic sepsis syndrome may occur. (150) Delayed diagnosis may lead to reduced function, increased morbidity and the need for more complex surgery, often involving multiple procedures.(150)

The orthopaedic community and wider healthcare team have adopted many interventions and strategies to decrease PJI. Preoperatively, decolonization of patients with Staphylococcus aureus, optimization of medical management of comorbidities, and nutritional optimization are performed. Perioperatively and intraoperatively, prophylactic antibiotic administration, skin preparation, laminar air flow, boy exhaust suits, minimization of operative room personnel, and antibiotic-loaded cement are used. Postoperatively, measures used include administration of antibiotics, management of bleeding and appropriate blood transfusion practices, and early discharge from hospital.(151)

Late infections, often of haematogenous aetiology, may present more insidiously with worsening joint pain, effusion and restriction of movement.(150) Haematogenous seeding of a bacteraemic infection to a prosthesis is rare overall, and transient bacteraemia is not likely to result in PJI in otherwise healthy patients.(152) However, chronic infections and patients with other medical comorbidities have a higher likelihood of developing late PJI.(152) The rate of PJI is further increased if the haematogenous organism is Staphylococcus aureus, with PJI rates as high as 34%.(149, 150)
Diagnosis of PJI – The diagnostic criteria for PJI remains controversial, despite ongoing research and developments into the diagnosis and management of PJI. A consensus statement from the Infectious Diseases Society of America(153) in 2012 suggests preoperative testing to include a thorough history and physical examination, ESR and/or CRP test, radiographic evaluation, and arthrocentesis with synovial fluid analysis. Blood cultures and advanced imaging should be considered on an individual case basis, and not

part of routine assessment. Intraoperatively, histopathological examination of minimum 5-6 tissue samples, and/or the explanted prosthesis will maximize the likelihood of microbiologic diagnosis.

The definition of PJI includes:

- A sinus tract which communicates with the prosthesis, or
- Acute inflammation on histopathological examination or periprosthetic tissue as determined by the attending pathologist, or
- The presence of purulence surrounding the prosthesis without another known aetiology, or
- 2 or more intraoperative cultures demonstrating the same organism. An organism which is known to be a common contaminant should not result in a definitive diagnosis of PJI.(153)

The Musculoskeletal Infection Society (MSIS) criteria, published in 2011 and updated in 2018, details the currently accepted criteria for PJI diagnosis. (148, 154)

Diagnosis of PJI can be made when 1 Major criterion are present:

- Sinus tract communicating with the prosthesis, or
- Pathogen isolated by culture from 2 separate tissue / fluid samples from the affected joint.

When Major criteria are not met, the presence of Minor criteria can be used. ≥ 6 points demonstrate PJI, 2-5 points are considered inconclusive, 0-1 points suggest absence of PJI. Minor criteria defined as:

- Serum CRP >1mg/dL – 2 points
- Serum D-dimer >860ng/mL – 2 points
- Serum erythrocyte sedimentation rate >30mm/h – 1 point
- Synovial white cell count >3000 cells/uL – 3 points
- Synovial alpha-defensin ratio >1 – 3 points
- Synovial Leukocyte esterase ++ - 3 points
- Synovial polymorphonuclear ratio >80% - 2 points
- Synovial CRP >6.9mg/L – 1 point

Organisms commonly identified in TKA PJI are Staphylococcus aureus (31.2-39%), coagulase-negative staphylococci (15-29.35), streptococci (6-10.9%), and gram-negative bacilli (4-12.7%). PJI is deemed polymicrobial in 9-12.3% of cases. 0.5-19% of cases are culture negative.(155)

Consensus for the management of PJI is yet to be reached amongst the orthopaedic and wider medical community. Current guidelines suggest the need for accurate diagnosis, prompt referral to a specialist service, and appropriate surgical intervention combined with antibiotic therapy.(153, 156-159)

Ongoing investigation and discussion within the orthopaedic community includes consideration of single-stage revision for infection, in comparison to the previously widely accepted utilization of 2-stage revision.
Qasim et al published a review of the literature regarding single stage revision for infection, and determined the significant factors contributing to failure of single stage RTKA for infection include the presence of a sinus, immunocompromised patient, delay between onset of symptoms and revision, staphylococcal infection, multiple debridement procedures, retention of exchangeable component, and short antibiotic duration.(160) Wolf et al assessed the QALY difference between single-stage and 2-stage revision for infection in hip arthroplasty using a Markov decision model, and suggested improved patient outcomes with single-stage management. Despite their findings, the authors suggest that ‘it would not be appropriate to recommend a sweeping change in practice patterns.’(161)

The timing of re-implantation (second stage) of RTKA for infection is poorly supported by the use of serological markers such as Erythrocyte Sedimentation Rate (ESR) and C-Reactive Protein (CRP) or joint aspiration.(144) The standard period of antibiotic administration prior to second stage re-implantation is a minimum of 6 weeks. The successful eradication rate of infection with a 2 stage re-implantation RTKA varies between 75% to 97.4%, with high volume centres reporting up to 94%.(115, 162)

The functional outcomes of RTKA due to infection are poorer than those for aseptic revision, with up to 50% of patients complaining of a poor outcome despite successful eradication of the infection.(114-119) The poorer outcomes of septic RTKA patients was

attributable to decreased range of motion and functional capabilities. There was no significant difference in reported pain.(9, 117, 163)

The likelihood of developing a subsequent infection following RTKA for infection is significant. The literature states reinfection rates of between 5.8 and 25%.(119, 140, 144, 162, 164, 165) The average time to failure due to recurrent infection varies between 50 weeks and 2.6 years.(140, 144, 162, 165) The overall survival of RTKA for infection is reported as 71% at 5 years, and 64% at 10 years. (140, 165) This is markedly lower than RTKA for non-infected causes, which has a survival rate reported at 85% at 5 years, and 77% at 10 years.(13)

The likelihood of developing infection after RTKA for any cause of primary TKA failure, compared to primary TKA, is significantly increased.(155, 166)

2.4 Similar studies

6 published studies with aims and methodologies similar to our research were identified (See Table 5).

Barrack et al(117) report outcomes following 125 RTKAs with mean follow up of 36 months. RTKA surgery was performed by 3 surgeons at 3 facilities, using a single prosthesis type. Patients who underwent RTKA for infection had poorer postoperative functional and clinical outcomes. Despite these differences, satisfaction was similar between groups.

Mortazavi et al(167) investigated the main cause of failure of RTKA, with infection being identified as the major cause. 499 RTKAs were reviewed, at a mean of 64.8 months follow up. There was no standardisation of surgeon or prosthesis used. 18.3% of RTKAs failed and required further surgery, with infection being the major cause (44.1%). The majority of failures were found to occur within 2 years of RTKA.

Bieger et al(168) reported on 102 RTKAs performed with a mean follow up of 29 months. All patients received the same prosthesis, but no standardisation of surgeon was reported. There was no difference found in postoperative outcome measures based on reason for

RTKA, with the authors suggesting that similar results for all RTKA patients can be expected.

Bae et al(169) published on 224 RTKAs performed by a single surgeon, using a single prosthesis, over a period of 19 years. The average follow-up was 8.1 years. The causes for revision and the long-term outcomes were investigated. 20 knees required further revision surgery, with a 5-year survival rate of 97.2%, and 10-year survival rate of 86.1%. Infection and loosening were the most common causes of failure of RTKA.

Rajgopal et al(170) described no significant difference of outcome measures between RTKAs for septic or aseptic cause of failure. A retrospective review of 142 patient charts was conducted, with mean follow up of 73 months. There was no standardisation of implant prosthesis used, or distinction of outcome measures between prosthesis subgroups. They concluded that septic failure does not preclude good outcomes of RTKA.

Van Kempen et al(171) describe the 2 year outcomes of 150 RTKA patients, using 2 different prostheses at 2 different facilities. There was no standardisation of surgeon performing the procedures. Outcome measures were compared between reason for RTKA groups. The KSS functional score and ROM did not demonstrate statistically significantly correlation between groups. Overall, different outcomes were found between groups, with best results in aseptic loosening group, and poorest results in the stiffness group.

Author	Number of RTKAs	Follow up duration	Number of surgeons	Number of institutions	Number of prosthesis types	Assessment methods	Key findings
Barrack (2000)	125	Mean 36 months	3	3	1	Clinical assessment and chart audit	Improved outcomes for aseptic vs septic RTKA. Patient satisfaction equal for aseptic vs septic RTKA.
Mortazavi (2010)	499	Mean 64.8 months	Unspecified	Unspecified	Unspecified	Chart audit	18.3% failure of RTKA. 44% infection as cause of failure. Majority of failures within 2 years postoperatively.
Bieger (2012)	97	Mean 29 months	Unspecified	1	1	Unspecified	Functional score improvement post RTKA. No difference in outcomes based on reason for revision.
Bae (2012)	224	Mean 8.1 years	1	1	1	Clinical assessment and chart audit	5 year survival 97.2%. 10 year survival 86.1%. Infection and loosening most common causes of RTKA failure. Lower survival with decreased age.
Rajgopal (2013)	142	Mean 73 months	1	1	Unspecified	Clinical assessment and chart audit	No significant difference in outcome measures for aseptic vs septic groups.
Van Kempen (2013)	150	24 months	Unspecified	2	2	Clinical assessment and chart audit	Reason for RTKA predicts clinical outcomes post RTKA.

TABLE 1 – Similar studies

ETHICS APPROVAL

Ethical approval for this research was obtained through the Greenslopes Private Hospital Human Research Ethics Counsel (HREC). Ethics approval was also obtained though the Bond University HREC. This ethical approval was obtained prior to any patient information being accessed.

GPHREC approval number: Protocol 15/77 ‘Long term outcomes following revision total knee arthroplasty’
BUHREC approval number: 0000015604 ‘Long term outcomes following revision total knee arthroplasty’

Ethical considerations for this research:

Modern biomedical ethics has been structured and guided by three publications pertaining directly to the advancement and clarification of ethically appropriate research. The Nuremberg Code, Declaration of Helsinki, and Belmont Report have shaped biomedical research into the practice we apply today. (172-175)

Biomedical ethical principles developed in the above mentioned publications were used as the foundation of ensuring an ethical research protocol and methodology in the current research project. The practical application of these principles has been integrated into the study design, with particular attention to ethical considerations for current study participants. Also considered are the potential implications of research findings on the individual, as well as the wider community.

Patient confidentiality was maintained throughout the research project, through the use of de-identified information and appropriate limitations of access to this information.

Patient autonomy was maintained by giving a description of the research project and obtaining consent from the patient when first contacted by telephone. 4 patients declined to participate. No patients were coerced or pressured into participation. Patients were offered a written copy of study details to be sent by postal mail.

The inclusion criteria of this study is broad, aiming to involve all appropriate patients, whilst the exclusion criteria of this study is based solely on prior surgical care provided, thus eliminating concerns regarding patient demographics. Due to the retrospective nature of this study, there is no concern regarding the provision of health care for study participants.

Individual involvement in this research project does not directly benefit the patients involved, as their outcomes are those which will provide the data for analysis. The process of data collection did enable patients who have poor outcomes to be identified and therefore prompt further consultation if deemed appropriate by the patient and surgeon. Involvement in this research does benefit future patients, by allowing for a valuable contribution to orthopaedic literature and understanding of RTKA outcomes, thereby enabling better informed consent for patients in the future.

Involvement in this research does not place the participants in any identifiable harm. It will not have an impact on future care by the researchers, and individual patient details will not be made available to any third party. The estimated length of involvement required for participation is 10 minutes of telephone conversation.

Ethical implications of research study and outcomes

This study aimed to impact on clinical practice by contributing to the literature regarding results following RTKA procedures. The effects of better informed clinicians, is to facilitate better informed patients and clinical decisions. The undertaking of RTKA surgery must be founded on well informed patients and clinicians, with realistic expectations of postoperative outcomes. The likely benefit must outweigh the risks, albeit not excluding the potential negative outcomes.

While the actual implications of our results are currently unknown, the contribution of quality clinical research to the knowledge of clinical decision makers is supremely valuable. An increase in the breadth and depth of knowledge surrounding RTKA will result in better-informed discussions and decisions regarding RTKA for future patients.

CHAPTER 3: METHODOLOGY

The goal of this research is to establish an understanding of current patient satisfaction following RTKA, as well as to identify factors which may have contributed to outcomes following RTKA. To achieve these goals, a 2 stage data collection process was used, firstly a telephone questionnaire and satisfaction assessment, followed by a comprehensive retrospective chart review.

Operative and booking records were used to identify patients eligible for inclusion in this study. All patients who had undergone a RTKA at John Flynn Private Hospital, performed by Dr Raymond Randle (Clinical Supervisor), receiving the PFC (Depuy) prosthesis, with a minimum of 2 years post-operatively were included in this study. All patients were privately insured.

All patients who met the inclusion criteria were included in the chart review and data analysis process.
Exclusion criteria from functional and satisfaction assessment were: further surgical intervention by a different surgeon since RTKA surgery by Dr Randle, patients who have undergone re-revision by Dr Randle but utilizing a different prosthesis type, patients who are deceased or uncontactable, and patients who did not wish to participate in this study.

The first stage of data collection involved a telephone interview of patients, obtaining consent and then completion of a structured assessment questionnaire (See appendix). This assessment questionnaire was developed based on patient specific outcomes, including completion of the Oxford Knee Score(126) (OKS) and satisfaction outcome scores including the Mahomed Satisfaction Scale(133) and other simple assessments of patient satisfaction previously used by other authors(176). Patients were also able to make personal comments which were recorded. Telephone assessment involved discussion for less than 15 minutes per patient in most cases.
The use of a telephone questionnaire eliminated the need for patients to travel for assessment. This is particularly relevant due to the nature of RTKA referrals, with many patients included in this study not residing within the local area of Dr Randle's private practice. The use of telephone assessment eliminates the need for patients to travel, therefore increasing follow up rate and minimising inconvenience to patients. This consideration was also important when determining the most appropriate outcome score.

The OKS does not require clinical assessment, which was a significant impacting factor in choosing this clinical tool.
The OKS is typically performed by patients alone and without assistance, which allows for patient scoring to be affected by limitations of reading and / or comprehension. This was eliminated in this research project via repetition or clarification if required by the patient.

The telephone questionnaire data collection was conducted prior to chart review due to the age of this patient cohort, and the presumed higher follow up rate with earlier contact.
We identified 202 RTKAs in 178 patients which met the above mentioned inclusion criteria. At time of telephone review 27 patients were deceased, 14 were unable to be contacted by telephone, and 4 patients declined to participate. The remaining 133 patients underwent telephone satisfaction and functional assessment (see figure 14).

The second stage of data collection involved a retrospective chart review of all patients who met inclusion criteria, utilising orthopaedic records as well as hospital records. We developed a structured assessment tool, designed to capture data which we deemed appropriate and specific to RTKA outcomes and survivorship, and supported by other authors(137, 168, 177-184) (See Appendix).

Orthopaedic specific data was collected by Dr Randle pre-operatively, peri-operatively, and post-operatively. Dr Randle's usual practice involves postoperative assessment of patients until 1 year following RTKA surgery. At this time point, patients are discharged to their general practitioner with instructions to return if any concerns arise. Alternatively, patients with current or ongoing clinical issues at 1 year postoperatively are followed up further based on clinical need. This data set was recorded at the time of care provision by Dr Randle. All records were reviewed independently by the primary investigator. Range of motion outcomes were determined by the clinical assessment at 1 year postoperatively. This was measured with the use of a goniometer, and documented by Dr Randle.

Hospital records were retrieved from medical records at the treating institution. Data was reviewed by the primary investigator, utilising the data collection tool. These records enabled the collection of patient information not included in the orthopaedic records, as well as confirmation of previously collected information. There were no discrepancies identified between data records.

Patient charts are stored in a secure facility and confidentiality was maintained throughout the data collection period as per ethics approval.

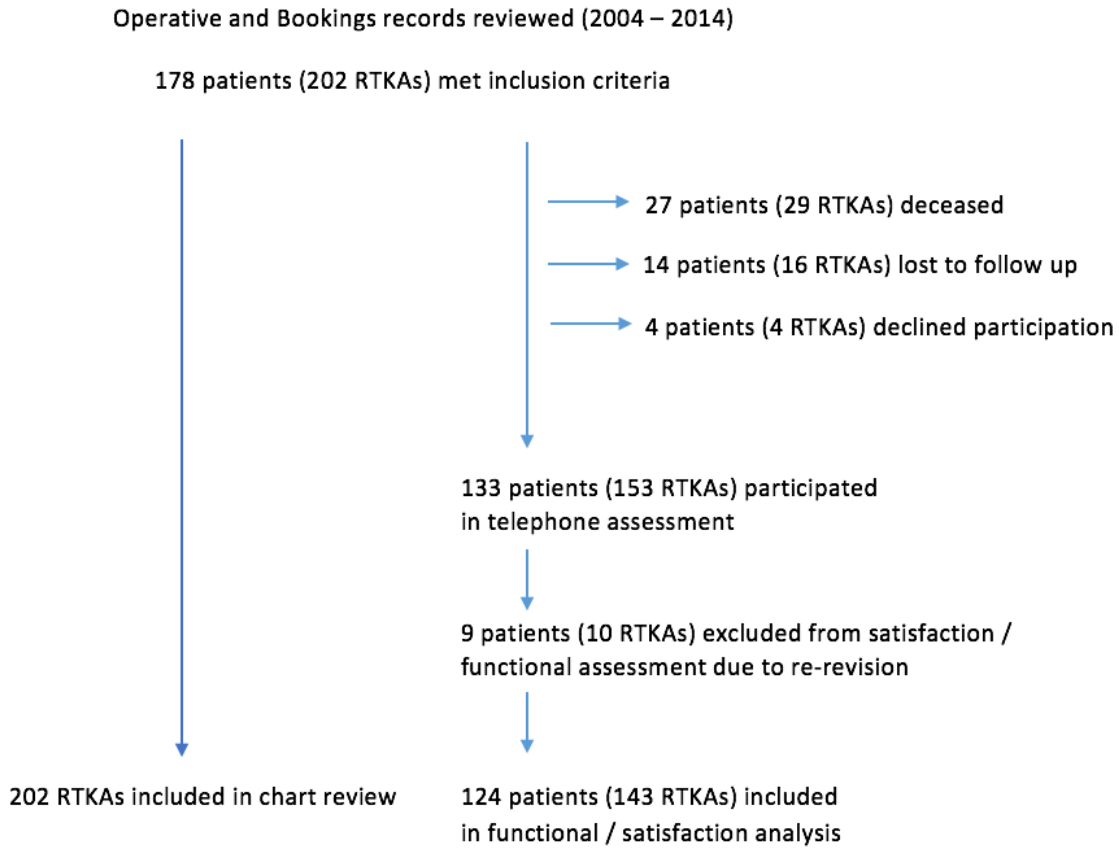

Figure 2 – Patient inclusion methodology

3.1: RESEARCH QUESTIONS / HYPOTHESIS

This research project is aimed to provide greater insight into likely patient outcomes following RTKA. It has been designed to assess the mid to long term outcomes, including failure of RTKA, patient satisfaction and functional ability. A number of potential influencing factors on postoperative outcomes have been identified from the literature and are investigated in this patient cohort.
We review the outcomes of a single experienced arthroplasty surgeon, at a single institution, utilising a standardised surgical technique and single prosthesis type. This enables us to remove confounding factors which have impacted other authors, including multiple surgeons, operative sites, operative techniques, and prostheses used.

Our primary objective is to investigate the survivorship of RTKA. This is achieved through firstly identifying the rate of re-revision within this cohort. We also report the reason for failure of RTKA within patients undergoing re-revision, as well as the impact of previous RTKA surgery on postoperative outcomes.

Our secondary objectives involve investigation of patient reported outcomes following RTKA and identification of factors which impact patient outcomes within the RTKA cohort. This is achieved through analysis of patient reported outcome measures, such as the Oxford Knee Score, clinical assessment of range of motion preoperatively and postoperatively, and patient satisfaction scores.
The specific intraoperative requirements for each patient are assessed and analysed to identify significant correlations between patient factors, surgical factors and outcome measures.

Patient satisfaction is then investigated through the analysis of patient reported satisfaction scores. Different assessment methods are analysed to identify the correlation between methods of assessment. We then examine the impact of patient characteristics, intraoperative factors, and postoperative functional outcomes on patient satisfaction.

Further objectives of this research include analysis of qualitative feedback from patients regarding their personal experience of RTKA. While this is descriptive in nature, it provides insight and direction into patient-centred care for future RTKA patients.

This research also describes in detail the operative approach and perioperative care of RTKA patients in this cohort. This aims to describe in detail the techniques developed in response to the known adverse outcomes that arise from RTKA surgery, and to report on the complication rate postoperatively. We expect that these techniques will be widely applicable and reproducible in the RTKA setting, will have a low complication rate postoperatively, and will enable other surgeons to consider utilising similar techniques during RTKA procedures in the future to improve patient outcomes. While comparison of the described surgical technique with an alternative technique is beyond the nature and scope of this research, appropriate description provides this opportunity in the future.

Within the discussion section of this thesis, we also describe some of the practical considerations which the senior author, Dr Randle, considers important to obtaining a successful postoperative outcome following RTKA. This discussion will be based primarily on the extensive experience of Dr Randle in complex RTKA.

Overall, this research project aims to provide valuable insight into the post-operative outcomes following RTKA, and factors which contribute to positive or negative patient outcomes. This information will enable clinicians to be well informed, thus facilitating appropriate counselling of patients regarding their likely postoperative outcomes. This is a vital part of obtaining informed consent and managing patient expectations. We believe that this research will be a valuable contribution to knowledge, discussion and patient-centred care in RTKA.

Specific Research Questions:

In this RTKA cohort,

Do patient characteristics or preoperative factors impact on required surgical intervention intraoperatively?

Is postoperative function impacted by preoperative, intraoperative, or postoperative factors?

Is survivorship of RTKA impacted by preoperative, intraoperative, or postoperative factors?

Does preoperative and early postoperative ROM predict later postoperative ROM?

Does overall patient satisfaction result in different scores on other satisfaction measurement outcome tools?

Is there a significant difference in postoperative function / functional scores between satisfied and dissatisfied patients?

What factors (patient characteristics, preoperative, intraoperative, or postoperative) may predict postoperative satisfaction?

What key features are significant for patients in their 'lived experience of RTKA'?

What is the complication rate and postoperative outcomes for patients receiving this surgical approach / technique?

Hypotheses:

We hypothesise that, in this RTKA cohort,
Pre-operative ROM may impact on the intraoperative interventions required, and therefore impact on the choice of implant, use of augments, polyethylene thickness, and overall surgical time.

OKS would be impacted by pre-operative and intraoperative variables.
Implant type would impact on postoperative outcomes (OKS, ROM).

Subsequent failure of RTKA would not be significantly impacted by pre-operative variables.

Postoperative ROM would be impacted by preoperative and intraoperative factors, and that correlation would be significant between preoperative, early postoperative, and later postoperative ROM.

Patient reported numerical score (Score 1-10) and Mohamed Satisfaction Scale (MSS) will demonstrate significant difference between satisfied and dissatisfied patient groups.

ROM and OKS will have statistically significant difference between satisfied and dissatisfied groups, and OKS will correlate with Score 1-10 and MSS.

Patient satisfaction will be influenced by patient characteristics, preoperative variables, intraoperative variables, perioperative variables, postoperative outcomes, and postoperative complications.

Patients will report common themes or influential factors to their personal 'lived experience' of RTKA surgery.

Patients in this cohort will demonstrate a low complication rate and high quality postoperative outcomes.

Testing of hypotheses / Analysis methods:

Data collection included 75 specific variables. These included patient characteristics, preoperative variables, intraoperative variables, postoperative variables, postoperative outcomes, and satisfaction assessment outcomes. Data collection templates are available within the appendix of this thesis.

SPSS (IBM) was used for statistical analysis. Previous orthopaedic publications were used to guide statistical analysis techniques, and thereby ensure consistency of methodology within the wider body of literature.
Key outcome variables were assessed for normality utilising visual (histograms, normal Q-Q plots) and statistical analysis (Shapiro-Wilk) methods.

Statistical testing methods include Mann-Whitney test for two independent groups, Wilcoxon Signed Rank test for assessment of means of matched samples, Kruskal-Wallis test for means of three or more independent groups, Spearman Correlation Coefficient for relationship between continuous variables, Chi-squared test for relationship between categorical variables, Binary logistic regression for independent variables as predictors of

outcome (Forward stepwise modelling and backwards stepwise elimination modelling was used).

Patient comments were analysed following completion of data collection. The patient comments were reviewed and classified based on the primary themes identified using a combination of thematic and content analysis approaches.(185)Validation / verification strategies were adopted to support the methodology and reporting of results.

Detailed description of surgical technique is combined with descriptive results of patient demographics, intraoperative details and postoperative outcomes.
This method is intended to facilitate adoption or comparison with other surgeons / techniques.

Further description of research questions, hypotheses, and analysis methods are included in respective chapters.

There were no significant costs involved in this project.
There were no changes to study design, methodology, data collection / storage, or ethical approvals following beginning of data collection.
Data is currently stored in a de-identified manner, in a secure location. Data will be retained for 15 years from completion of study in its current form, as per ethical approval.

CHAPTER 4: POSTOPERATIVE OUTCOMES FOLLOWING REVISION TOTAL KNEE ARTHROPLASTY

Abstract

Introduction / Background:

The outcomes following primary total knee arthroplasty (TKA) have been well documented and published, however the longer term outcomes of revision total knee arthroplasty (RTKA) are less robustly supported by the literature.

The paucity of information available to guide the patient and the surgeon in decision-making and postoperative expectations for RTKA is a current challenge for orthopaedic surgeons.

We investigated the mid to long term outcomes in patients undergoing RTKA by a single surgeon (RR), using a single prosthesis design (PFC, Depuy), at a single institution.

We also identified factors which may contribute to intraoperative management decisions and patient outcomes.

Methods:

A retrospective review of hospital and orthopaedic records was combined with completion of a structured telephone assessment questionnaire, including Oxford Knee Score (OKS) and satisfaction assessment. Postoperative range of motion was determined at 1 year following RTKA.

Inclusion criteria were: RTKA (major) performed by the senior author (RR), PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA.

Results:

202 RTKAs were performed in 178 patients between 2004 and 2015 inclusive. 153 RTKAs (133 patients) were available for assessment. This cohort demonstrated a survival rate of 93.5% at a mean 6.5 years since RTKA surgery. 85% of patients were satisfied with their postoperative outcome.

Postoperative functional outcomes, assessed at 1 year postoperatively, demonstrated a mean OKS of 39.25 (range 14-48). Mean ROM increased from 100 degrees (range 5-145)

preoperatively to 112 degrees (range 35-135) postoperatively. This difference was statistically significant (Wilcoxon Z = -6.438, p<0.001)

Statistically significant increased postoperative OKS was found in male patients, patient with fewer previous RTKA surgeries, those with increased pre-operative ROM, and less constrained implant.

Postoperative ROM demonstrated a statistically significant difference depending on pre-operative ROM, reason for revision and number of previous RTKA surgeries.

Implant type demonstrated a protective effect on failure of RTKA, with hinged implants having higher rate of failure. Pre-operative ROM had little effect on intraoperative variables.

Conclusion:

This study gives a comprehensive review of outcomes following RTKA in a large patient cohort with a long follow up. The preoperative, intraoperative and postoperative characteristics can be used to guide understanding of the factors impacting on patient outcomes following RTKA. Although RTKA is a challenging and complex aspect of arthroplasty surgery, high patient satisfaction and good functional outcomes can be achieved in the majority of patients.

4.1 Introduction:

The long term outcomes following revision total knee arthroplasty (RTKA) and factors which contribute to these outcomes remains an area of important research in Orthopaedics.

While the outcomes following primary total knee arthroplasty (TKA) have been well documented and published, the long term outcomes of RTKA is less robustly supported by the literature. RTKA has been shown to result in considerable improvement in outcomes in comparison to the pre-RTKA outcomes.(114)

The factors affecting outcomes following RTKA are poorly understood(136). However, it remains widely accepted that RTKA is a challenging surgical procedure(9, 10), and that

postoperative outcomes are poorer than for primary TKA(9-12). The reasons for increased difficulty of surgery and poorer outcomes has been attributed to difficult surgical exposure, stiffness, adhesion of tissues, instability due to ligamentous laxity and poor bone stock.(10) The revision procedure “imparts an additional burden of disability” onto patients, and accordingly “most revision patients will never experience an outcome as favorable as their primary procedure”.(11)
The paucity of information available to guide the patient and the surgeon in decision-making and postoperative expectations for RTKA is a current challenge for orthopaedic surgeons.

We aim to investigate the mid to long term outcomes in patients undergoing RTKA by a single surgeon (RR), using a single prosthesis design (PFC, Depuy), at a single institution. We also aim to identify factors which may contribute to intraoperative management decisions and postoperative outcomes.

4.2 **Methods**:

Ethical approval was obtained from institutional HREC (BUHREC approval number: 0000015604). Patients were identified through operative and clinic booking records. A planned 2-stage RTKA for infection was considered a single RTKA for research purposes. Patients were contacted by telephone to obtain consent and then completion of a structured assessment questionnaire, including the Oxford Knee Score (OKS). A chart review of hospital and orthopaedic documentation was then conducted to identify other key data. Postoperative range of motion was determined at 1 year post RTKA.
Range of motion was assessed with the patient supine, and a goniometer was used for all measurements.

Inclusion criteria were: Revision TKA (Major) performed by the senior author (RR), PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA. Patients were excluded if they had received a subsequent re-revision by a different surgeon.

SPSS version 26 (IBM) was used for statistical analysis.

The following data was collected and used for analysis of patient outcomes.

Preoperative:

- Gender
- Patient age
- Patient weight
- Patient BMI
- Primary TKA Cause of Failure
- Number of prior revisions
- Pre RTKA ROM total

Intraoperative:

- Prosthesis type (CR, PS, TC3, Hinge)
- Polyethylene insert thickness
- Stemmed implants used
- Bone augments used
- Artificial augments used
- Surgical time

Postoperative:

- Oxford Knee Score (OKS)
- 3 months post RTKA ROM total
- 1 year post RTKA ROM total
- Failure of RTKA / Further surgery required
- Cause of failure of RTKA

4.3 Distribution of outcome variables:

Key outcome variables were assessed for normality utilising visual (histograms, normal Q-Q plots) and statistical analysis (Shapiro-Wilk) methods, and found to be non-normally distributed. The data collected was markedly skewed, and therefore transformation was not able to restore the data to a normal distribution. Despite multiple transformation attempts, the obtained data sets still fail the formal tests of normality. Therefore, we have adopted non-parametric analysis for these outcome measures.

The use of non-parametric testing therefore includes Mann-Whitney test for two independent groups, Wilcoxon Signed Rank test for assessment of means of matched samples, Kruskal-Wallis test for means of three or more independent groups, Spearman Correlation Coefficient for relationship between continuous variables, and Chi-squared test for relationship between categorical variables.

Data analysed included pre-operative, intraoperative, and postoperative variables. Our primary objective of statistical analysis was the identification of significant factors (pre-operatively and intraoperatively) on postoperative outcomes.
Statistical analysis was conducted to determine the impact of pre-operative variables on post-operative outcomes, intraoperative variables on postoperative outcomes, and pre-operative variables on intraoperative / surgical factors.

The most important postoperative outcome variables to our analysis include OKS, ROM at 3 months, ROM at 1 year, and Failure of RTKA.

We predicted that the following independent variables may contribute to the dependent variable outcomes:

- Gender
- Age
- Weight
- BMI
- Primary TKA cause of failure / Reason for revision
- Number of previous RTKAs
- Pre-RTKA ROM
- Prosthesis type
- Polyethylene thickness
- Surgical time

Regression modelling was considered to assess the impact of independent variables, however due to the nonparametric nature of dependent variables, this was not appropriate in some analyses.

Therefore, assessment of independent variables' effect on dependent variables was performed through the use of Mann-Whitney test, Wilcoxon signed rank test, Kruskal-Wallis test, Spearman correlation coefficient, and Chi-squared test, chosen based on data type.

4.4 Assessment of dependent variables (Oxford Knee Score, 3 month ROM and 1 year ROM) involved a combination of Mann-Whitney test, Kruskal-Wallis test, and Spearman's rho correlations testing.

Research Questions:

In this RTKA cohort, is postoperative functional assessment (OKS) impacted by preoperative and /or intraoperative factors?

In this RTKA cohort, does implant type impact postoperative functional assessment (OKS)?

In this RTKA cohort, is post-operative ROM impacted by preoperative and intraoperative variables?

In this RTKA cohort, is postoperative ROM impacted by preoperative ROM? Does early postoperative (3 month) ROM impact on late postoperative (1 year) ROM?

In this RTKA cohort, do preoperative variables impact survivorship of RTKA?

In this RTKA cohort, does pre-operative ROM predict or impact on intraoperative surgical care (implant type, polyethylene thickness, augment use, surgical time)?

Hypotheses:

Oxford Knee Score - We hypothesise that OKS would be impacted by pre-operative and intra-operative variables. Pre-operatively, we considered previous RTKA surgeries, ROM, and Cause of failure to likely affect OKS. We expect that increased previous RTKA

surgeries would decrease OKS, increased ROM would increase OKS, and lower OKS for stiffness and pain groups.

We further hypothesised that implant type would affect OKS, with higher OKS for less constrained implants (CR, PS), and lower OKS for hinge implant.

3 Month and 1 year (postoperative) ROM - We hypothesise that 3 month ROM and 1 year ROM would be significantly affected by Reason for revision, Number of previous RTKA surgeries and Implant type variables.

Change in ROM over time - We hypothesise that preoperative ROM would be a significant correlating variable in postoperative ROM, and that 3 month ROM would demonstrate correlation with 1 year ROM.

Failure of RTKA - We hypothesise that failure of RTKA would not be significantly impacted by pre-operative variables.

Impact of pre op ROM on intraoperative factors - We hypothesise that pre-operative ROM may impact on the intraoperative interventions required, and therefore impact on the choice of implant, use of augments, polyethylene thickness, and overall surgical time. We hypothesise that decreased pre-operative ROM would result in increased use of augments, increased constraint of implant, and increased polyethylene thickness and surgical time.

Use of stemmed implants, bone augments and artificial augments - We hypothesise that increased use of stemmed implants, bone augments and artificial augments would increase surgical time. We also hypothesise that the use of stemmed implants, bone augments and artificial augments would increase with use of implants of increased constraint.
Multivariate regression analysis was used to assess for impact of stems and augments on implant type used.

Previous RTKA surgeries - We hypothesise that an increased number of previous RTKA surgeries would result in the used of an increased constraint prosthesis.

Results:

202 RTKAs were performed in 178 patients between 2004 and 2015 inclusive. 27 patients (29 RTKAs) were deceased at time of review, 14 patients (16 RTKAs) were unable to be contacted, and 4 patients (4 RTKAs) declined to participate. 153 RTKAs (133 patients) were assessed by telephone including OKS and satisfaction scores.
Patient characteristics, and intraoperative factors are summarised in tables 2 and 3 below.

	N=153
Gender (% Male)	57% (n=71)
Time since RTKA	6.5 years (range 2-13 years)
Age at time of review	74.8 years (range 49-98)
Age at time or RTKA	68.3 years (range 45-90)
Age at time of primary TKA	60.1 years (range 32-86)
Mean weight at time of surgery (kgs)	84.4 (range 50–130)
Mean BMI at time of surgery	29.9 (range 19-46)
Mean ASA score	2.4 (range 1-4)
Diabetic status	19 (2 T1DM, 17 T2DM)
Smoking status	5% current, 32% past, 63% never
Pre-op albumin	Mean 43.6, (range 31-56)
Reason for primary TKA	150 OA, 1 RA, 1 juvenile arthritis, 1 trauma
Number of prior revisions	26 patients had prior RTKA. Mean 0.22 (range 0-4)
Reason for RTKA	Loosening 51, Infection 34, Instability 14, UKA / PFJ progression of disease 13, Pain 11, Stiffness 5, Other 25.

Table 2 - Patient Demographics:

	N=153
Implant type (CR /PS / TC3 / Hinge)	43 CR, 73 PS, 29 TC3, 8 hinge
Polyethylene thickness	Mean 10.7mm (range 8-22.5mm)
Cemented prosthesis	All
Antibiotics in cement	All
Stemmed implants -	125 of 153 (99 Femur and Tibia, 4 Femur alone, 22 Tibia alone)
Bone augments used	67 of 153 (27 Femur and Tibia, 23 Femur alone, 17 Tibia alone)
Artificial augments used	84 of 153 (52 Femoral posterior condyle, 67 distal femur, 15 femoral sleeve, 4 medial tibial plateau, 15 tibial sleeve)
Surgical time	Mean 147 minutes (range 60 to 315)

Table 3 - Operative details:

Postoperative functional outcomes demonstrated a mean OKS of 39.25 (range 14-48). Mean ROM increased from 100 degrees (range 5-145) preoperatively to 112 degrees (range 35-135) at 1 year postoperatively. This difference was statistically significant (Wilcoxon Z = -6.438, $p<0.001$)

Oxford Knee Score

Males had a higher OKS postoperatively compared to females, (40.4 vs 37.6 respectively), which was statistically significant ($p=0.02$).

Patient age was not found to have a statistically significant impact on OKS ($p= 0.228$). Patient weight was not found to have a statistically significant impact on OKS ($p= 0.081$). Patient BMI was not found to have a statistically significant impact on OKS ($p= 0.314$).

The number of previous RTKA surgeries was found to have a statistically significant relationship with OKS, with increasing number of previous operations having a lower OKS postoperatively (Spearman's rho -2.71, $p= 0.001$).

Pre-operative ROM demonstrated a statistically significant relationship with postoperative OKS, with increased ROM being associated with higher OKS (spearman's rho 0.388, p = <0.001).

The Cause of failure of primary TKA was assessed for impact on OKS. Although differences in OKS between groups was found, this was not statistically significant (p=0.058).

Implant type was found to impact OKS, with highest OKS found in the CR group, followed by TC3 group, PS group, and lowest scores in the Hinged implant group. This finding was statistically significant (p= <0.001)

Polyethylene thickness did not demonstrate a statistically significant impact on OKS (Spearman's rho -0.068, p = 0.415).
Surgical time did not demonstrate a statistically significant impact on OKS (Spearman's rho 0.031, p = 0.720).

Independent variable	Dependent variable	Test	Statistical significance
Gender	Oxford Knee Score	Mann-Whitney	P=0.020
Age	Oxford Knee Score	Spearman Rho	P=0.228
Weight	Oxford Knee Score	Spearman Rho	P= 0.081
BMI	Oxford Knee Score	Spearman Rho	P=0.314
Reason for revision	Oxford Knee Score	Kruskal-Wallis	P=0.058
Previous RTKAs	Oxford Knee Score	Spearman Rho	-0.271, p= 0.001
Pre-operative ROM	Oxford Knee Score	Spearman Rho	0.388, p=<0.001
Implant type	Oxford Knee Score	Kruskal-Wallis	P= <0.001
Polyethylene thickness	Oxford Knee Score	Spearman Rho	P=0.415
Surgical time	Oxford Knee Score	Spearman Rho	P=0.720

Table 4 – Statistical analysis (1)

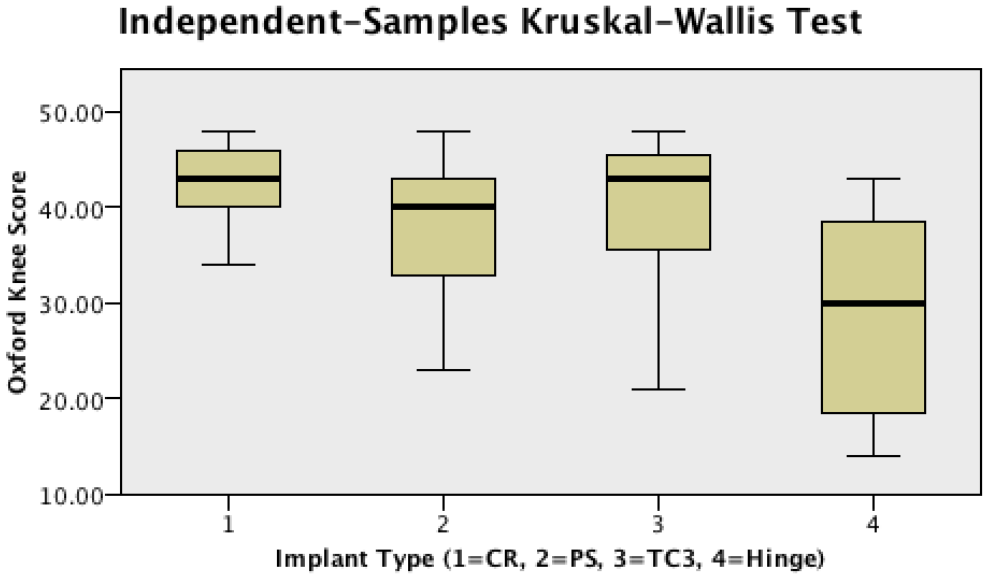

Figure 3 –Implant types and OKS

3 Month (postoperative) ROM

None of Gender, Age, Weight, or BMI demonstrated a statistically significant impact on 3 month ROM (p= 0.689 (gender), p=0.131 (age), p=0.302 (weight), p=0.944 (BMI). Number of previous RTKA operations did not demonstrate a statistically significant impact on 3 month ROM (p=0.370).

Reason for revision / cause of failure demonstrated a statistically significant difference between groups in 3 month ROM (p=0.004). ROM was lowest for the stiffness group, and greatest for the instability group.

Implant type approached but did not reach statistical significance for ROM at 3 months. The lowest ROM was found in the hinge prosthesis group, with greater ROM in the CR, PS and TC3 groups (p=0.053).

Polyethylene thickness and surgical time did not demonstrate a statistically significant difference on 3 month ROM (p= 0.323 and p= 0.455 respectively).

Independent variable	Dependent variable	Test	Statistical significance
Gender	3 month ROM	Mann-Whitney	P= 0.689
Age	3 month ROM	Spearman Rho	P= 0.131
Weight	3 month ROM	Spearman Rho	P= 0.302
BMI	3 month ROM	Spearman Rho	P= 0.944
Reason for revision	3 month ROM	Kruskal-Wallis	P= 0.004
Previous RTKAs	3 month ROM	Spearman Rho	P= 0.370
Implant type	3 month ROM	Kruskal-Wallis	P= 0.053
Polyethylene thickness	3 month ROM	Spearman Rho	P= 0.323
Surgical time	3 month ROM	Spearman Rho	P= 0.455

Table 5 – Statistical Analysis (2)

1 year (postoperative) ROM

Gender, Age, Weight and BMI all did not demonstrate a statistically significant impact on ROM at 1 year postoperatively (p=0.300 (gender), p=0.905 (age), p=0.094 (Weight), p=0.893 (BMI)).

Number of previous RTKA operations demonstrated a statistically significant impact on 1 year postoperative ROM (p=0.032). Increasing number of revision resulted in a lower ROM.

Reason for Revision demonstrated a statistically significant impact on 1 year ROM (p=0.007).
As was found at 3 months postoperatively, ROM was lowest in the group revised for stiffness, and greatest for the group revised for instability.

Implant type, polyethylene thickness and surgical time all did not demonstrate a statistically significant difference in ROM at 1 year postoperatively (p=0.097, p=0.386, p=0.543 respectively).

Independent variable	Dependent variable	Test	Statistical significance
Gender	1 year ROM	Mann-Whitney	P= 0.300
Age	1 year ROM	Spearman Rho	P= 0.905
Weight	1 year ROM	Spearman Rho	P= 0.094
BMI	1 year ROM	Spearman Rho	P= 0.893
Reason for revision	1 year ROM	Kruskal-Wallis	P= 0.007
Previous RTKAs	1 year ROM	Spearman Rho	P= 0.032
Implant type	1 year ROM	Kruskal-Wallis	P= 0.097
Polyethylene thickness	1 year ROM	Spearman Rho	P= 0.386
Surgical time	1 year ROM	Spearman Rho	P= 0.543

Table 6 – Statistical Analysis (3)

ROM pre-operatively, at 3 months postoperative, and at 1 year postoperatively

Related samples Wilcoxon Signed Rank testing was used to assess change in ROM between preoperative, 3 months postoperative and 1 year postoperative outcomes. When comparing these outcomes, statistical significance was found for a relationship between measurements for all comparisons (pre-operative vs 3 months Wilcoxon Z = -2.208, p=0.027, pre-operative vs 1 year Wilcoxon Z = -6.438, p= <0.001, 3 months vs 1 year Wilcoxon Z = -8.010, p= <0.001).

Pre-operative ROM	3 month ROM	Related-samples Wilcoxon Signed Rank	P=0.027
Pre-operative ROM	1 year ROM	Related-samples Wilcoxon Signed Rank	P= <0.001
1 year ROM	3 month ROM	Related-samples Wilcoxon Signed Rank	P= <0.001

Table 7 – Statistical Analysis (4)

Failure of RTKA

Binominal logistic regression was utilised to assess the impact of independent variables on the dependent variable ‘failure of RTKA’. The aforementioned independent variables were analysed. The model explained 44.6% (Nagelkerke R^2) of the variance and correctly classified 95.6% of cases. Only implant type demonstrated statistical significance, with a protective effect of CR, PS and TC3 implants (p = 0.039, 0.017 and 0.031 respectively). Patient age approached but did not reach statistical significance (p=0.068).
Impact of pre op ROM on intraoperative factors

Binary regression, multinomial regression and Spearman’s Correlation Coefficient testing was used to assess the impact of pre-operative ROM on intraoperative variables. The intraoperative variables assessed include:

- Use of stemmed implants
- Use of bone augments
- Use of artificial augments
- Implant type
- Surgical time
- Polyethylene thickness

In the assessment of pre-operative ROM as an impacting variable on use of stemmed implants, bone augments and artificial augment, the model poorly explained the relationship in all cases.
The use of stemmed implants was poorly explained by the model (Nagelkerke R^2 = 6.7%). However, the model correctly classified 82.6% of cases, and statistical significance was reached (p = 0.032).
The use of bone augments was also poorly explained by the model (Nagelkerke R^2 = 5.3%), with 55.7% of cases correctly classified. Statistical significance was reached (p = 0.021)
The use of artificial augments was poorly explained by the model (Nagelkerke R^2 = 4.8%), with 61.1% of cases correctly classified and statistical significance reached (p = 0.028).

Multinominal regression to determine the effect of pre-operative ROM demonstrated no statistically significant relationship between pre-operative ROM and implant type used (p = 0.934, Nagelkerke pseudo-R^2 = 39.5%). However, graphical depiction of pre-operative ROM vs implant type does suggest a correlation, likely unable to reach statistical significance due to outliers.

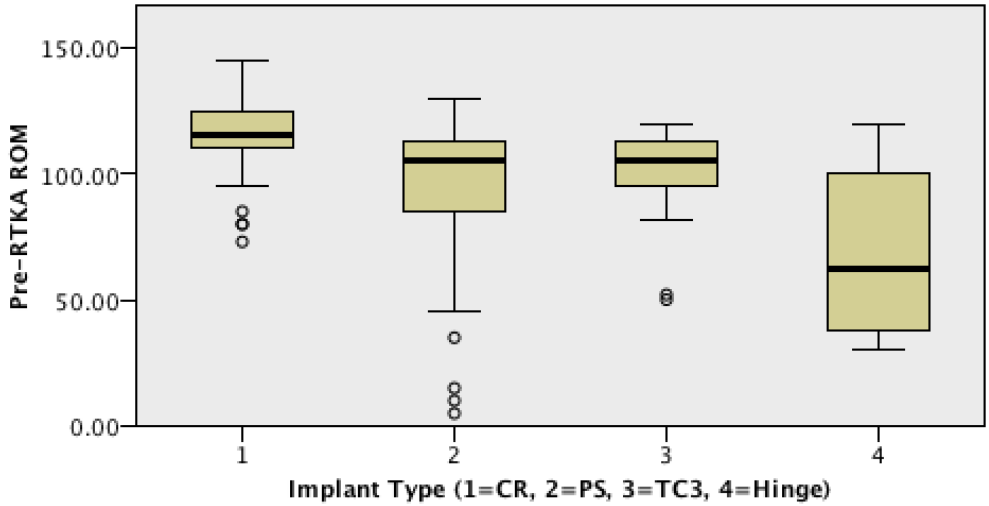

Figure 4 – Implant types and Preoperative ROM

Spearman rho demonstrated a statistically significant but weak correlation between pre-operative ROM and surgical time (rho = -.206, p = 0.016) and pre-operative ROM and polyethylene thickness (rho = -0.180, p = 0.028). As pre-operative ROM increased, surgical time and polyethylene thickness decreased.

Overall, pre-operative ROM does not demonstrate a significant impact the intraoperative implants used or surgical time.

Use of stemmed implants, bone augments and artificial augments

The impact of intraoperative factors, namely the use of stemmed implants, bone augments and artificial augments on implant type and surgical time was assessed.

Stems were used in 46.5% of CR implants, 93.2% of PS implants, 100% of TC3 implants, and 100% of hinge implants.
Artificial augments were used in 4.7% of CR implants, 72.6% of PS implants, 79.3% of TC3 implants, and 75% of hinge implants. No RTKAs had augments without stemmed implants.

A statistically significant correlation was found for the use of stemmed implants and artificial augments with prosthesis type (p=0.001 and p = <0.001, respectively). Nagelkerle R^2 explained 49% of variance. The use of bone augments did not demonstrate statistical significance (p=0.145).

The use of stemmed implants and artificial augments demonstrated an increased surgical time (Kruskal-Wallis p= <0.001 and p = <0.001 respectively). The use of bone augments did not demonstrate statistical significance (Kruskal-Wallis p=0.777).
Kruskal-Wallis test demonstrated a statistically significant difference in surgical time between implant types (p= <0.001), with longer times required as constraint of prosthesis increased.
ANOVA statistical testing was not appropriate given the non-parametric nature of “surgical time” data.

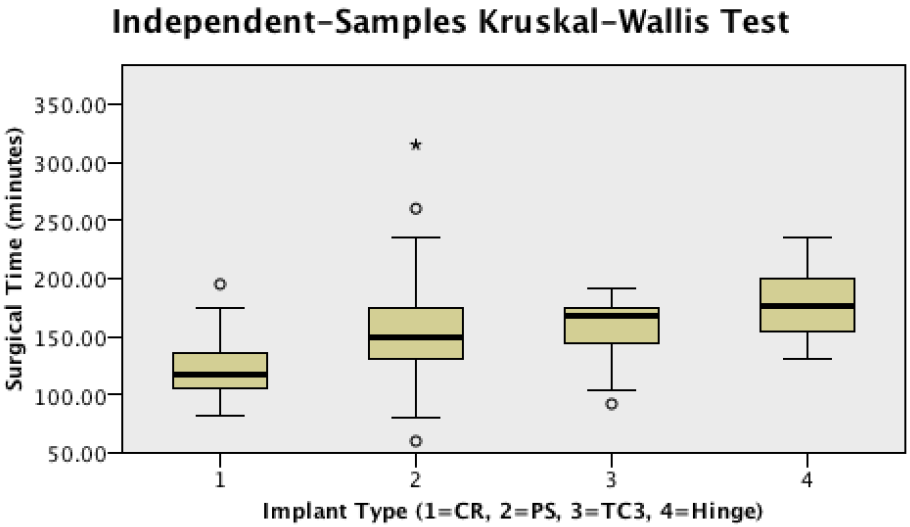

Figure 5 – Implant type and Surgical Time

Previous RTKA surgeries

Chi-squared test was used to assess correlation between the number of previous RTKA operations and the implant type. A statistically significant, moderate relationship was found between Previous RTKA and Implant type (Phi = 0.388, p=0.027), with increased constraint implant used as number of previous RTKA surgeries increased.

4.5 Post-operative outcomes:

Postoperative blood transfusion was required in 15% of RTKAs. Duration of hospital stay was a mean 7.6 days (range 3-42 days). 2 patients required readmission within 30 days of discharge. 19 patients had a postoperative complication within 90 days of surgery - 9 patients with stiffness requiring manipulation under anaesthesia, 6 superficial surgical site infections (1 requiring intravenous antibiotics), 1 postoperative pain, 1 wound dehiscence post fall, 1 haemarthrosis, 1 pulmonary embolism.

Survival rate of 93.5% was demonstrated within the patients who were able to be contacted by telephone. 10 RTKAs (9 patients) demonstrated failure of RTKA, requiring subsequent revision surgery. Hospital and Orthopaedic charts for all patients were reviewed, with no evidence of failure / re-revision in any patients unable to be contacted by telephone. 85% of patients were satisfied with their RTKA and stated that they would have their RTKA again.

Patients who underwent further revision surgery due to failure of RTKA were further analysed. 2 failures occurred within 1 year of RTKA surgery, both of these for infection. 6 RTKAs experienced failure within 5 years of index RTKA surgery, 4 due to infection, 1 periprosthetic fracture, and 1 impingement. 4 further failures occurred between 5 and 10 years following RTKA surgery, 2 for infection, 1 loosening, and 1 pain.
Overall, 6 of 10 failures occurred for infection, 1 periprosthetic fracture, 1 impingement, 1 loosening, and 1 for pain.

Within this cohort, 101 patients were available for 5 year or longer follow up from time of RTKA. The failure rate at 5 years post RTKA in our cohort is 6% (6/101).

Within our cohort, 25 patients were available for 10 year or longer follow up from time of RTKA. Of these patients, 10 patients (40%) have demonstrated failure of their RTKA. 6 of these 10 patients experienced RTKA failure due to infection. Unfortunately, it is not possible to directly compare our outcomes with the AOANJRR, as failure of RTKA information published excludes patients who previously underwent RTKA for infection. If excluding infection patients from our cohort, 4 of 19 (21%) patients experienced RTKA failure at 10 years, consistent with AOANJRR data (22.2%).(100)

Failure / Re-revision patients:

10 RTKAs in 9 patients have required re-revision. 8 RTKAs (7 patients) were re-revised by the senior author (RR) (5 for infection in 4 patients, 1 loosening, 1 periprosthetic fracture, 1 stiffness), 2 were re-revised by a different surgeon (1 pain, 1 single-stage liner exchange and debridement for infection). Patients who underwent further surgery had a higher rate of prior RTKA compared to the entire cohort (mean 0.8 vs 0.24).
Mean time from RTKA to re-revision was 4.5 years (range 0.6-10 years). Cases of re-revision for infection had mean of 3.6 years (range 0.6-8.2 years) between RTKA and re-revision. Non-infectious causes of re-revision had mean time of 5.7 years between RTKA and re-revision (range 2.3-10 years).
The re-revisions by RR are now a mean of 4.9 years (range 1-9 years) since re-revision, with a mean OKS of 35.2 (range 27-47). 5 of the 7 patients are satisfied with their RTKA.

4.6 Discussion:

This study gives a comprehensive review of outcomes following RTKA in a large patient cohort with a long follow up. The preoperative, intraoperative and postoperative characteristics can be used to guide understanding of the factors impacting on patient outcomes post RTKA.

All patients in this cohort received the PFC prosthesis (Depuy), by an experienced arthroplasty surgeon, at a single centre. Antibiotic cement was used in all cases. All patients had preoperative and intraoperative assessment for infection, and management of this was of primary concern, with patients undergoing insertion of antibiotic cement spacer

and subsequent second stage procedure if infection was detected. When a 2-stage procedure was undertaken, an articulating PROSTALAC spacer was used with cement stems to aid in stability. Within the published literature, there remains no consensus on superiority of options or techniques available for spacer use.(186, 187)

A planned 2-stage revision for infection (removal of implants with debridement and antibiotic cement spacer, followed by re-implantation of prosthesis after minimum 6 weeks of intravenous antibiotics) was considered 1 RTKA for research purposes.
All patients underwent preoperative planning, including having appropriate resources available intraoperatively if required, such as increased constraint implants, bone and artificial augments, and stemmed implants. The availability of these adjuncts intraoperatively facilitated the goal of appropriately addressing deficient bone stock or structural abnormalities, and enabling the final result of a balanced, stable, well-fixed prosthesis. This approach aligns with the principles of zonal fixation as described by Morgan-Jones et al.(108) Adherence to this principle was achieved by considering and optimising fixation of the revision implants into the epiphyseal, metaphyseal, and diaphyseal regions where possible. Preoperative planning and intraoperative availability of adjuncts for zonal fixation allowed all patients to achieve acceptable fixation. The methods utilised were selected based on an individual patient's requirements intraoperatively.

Our cohort of patients was similar to national averages regarding reason for revision (loosening 34%, infection 20%, instability 9%, progression of adjacent compartment disease 9%, pain 7%, polyethylene wear 6%, implant failure 5%, fracture 4%, stiffness 3%, malposition 3%) and international publications.(6, 80, 113, 142, 143)

Postoperative outcomes in this cohort demonstrate a high survival rate and satisfaction rate. The postoperative complication rate was low and unexpected readmission within 90 days occurred in only 2 patients. The revision rate within this patient cohort is comparable to national revision rate for primary TKA(100). National RTKA survival rates are significantly lower, with re-revision rates of 16% at 5 years and 23.8% at 10 years post RTKA, excluding patients who had initial RTKA for infection.(188) Current international literature suggests the overall complication rate for RTKA to be up to 26.3%, with 12.9% of RTKA requiring re-revision.(114)

This cohort demonstrated a statistically and clinically significant difference in ROM following RTKA. The mean 1-year ROM was 112 degrees, a clinically and statistically significant improvement compared to mean preoperative ROM of 100 degrees. The minimum clinically important difference in ROM post TKA is reported as 5 degrees.(189) Mean OKS at time of telephone review was 39.25, demonstrating a successful functional outcome. The New Zealand Orthopaedic Association arthroplasty registry includes OKS post TKA and RTKA, with the mean OKS post RTKA of 32.85, and a mean OKS post primary TKA of 40.43 at 5 years, 39.87 at 10 years.(190) The minimum clinically important difference in OKS post-TKA is reported as 5 points.(131, 191)

Within this cohort, increased number of previous RTKA procedures resulted in the use of more constrained implant type. Increasing implant constraint correlated with increased use of augments and stems, and increased surgical time. While use of CR implant resulted in improved OKS, there was no statistically significant difference found in postoperative ROM based on implant type. The use of a CR implant suggests that appropriate stability and balance was achieved intraoperatively without the need for an increased constraint prosthesis.

While preoperative ROM was not found to be a significant variable for intraoperative techniques, it was significant in predicting postoperative OKS and postoperative ROM.

Other authors have identified that ROM pre-RTKA was the most significant predictor of post-RTKA range of motion.(137) This is attributed to the difference in soft tissue envelope, and difficulty in obtaining ideal position and function of surrounding soft tissues.

Rajgopal et al(170) described no significant difference of outcome measures between RTKAs for septic or aseptic cause of failure in a retrospective review of 142 patient charts with mean follow up of 73 months. They concluded that septic failure does not preclude good outcomes of RTKA. Conversely, Barrack et al(117) report outcomes following 125 RTKAs with mean follow up of 36 months, finding that patients who underwent RTKA for infection had poorer postoperative functional and clinical outcomes. Despite these differences, satisfaction was similar between groups. Van Kempen et al(171) describe the 2 year outcomes of 150 RTKA patients, with best functional results in the aseptic loosening group, and poorest results in the stiffness group. We identified reason for

revision as statistically significant in postoperative ROM, and approached statistical significance for postoperative OKS.

Mortazavi et al(167) investigated failure of RTKA in 499 RTKAs with a mean follow up of 64.8 months. 18.3% of RTKAs failed and required further surgery, with infection being the major cause (44.1%). The majority of failures were found to occur within 2 years of RTKA. Similarly, Bae et al(169) published on 224 RTKAs performed by a single surgeon, using a single prosthesis, over a period of 19 years, with a mean follow-up of 8.1 years. They demonstrated a 5-year survival rate of 97.2%, and 10-year survival rate of 86.1%. Infection and loosening were the most common causes of failure of RTKA.

We believe that there are a number of factors which have contributed to the high quality outcomes for patients within our cohort. Firstly, all operations were performed by an experienced arthroplasty surgeon, familiar with the prosthesis and intraoperative insertion technique. Secondly, the prosthesis used has demonstrated high quality long term outcomes, with low revision rate over 15 years.(6) Thirdly, these patients underwent a well-structured postoperative physiotherapy and rehabilitation program within a private healthcare setting.

There are a number of considerations which the senior author (RR) adopts in the approach to RTKA surgery. Firstly, pre-operative diagnosis and intraoperative assessment for infection is critical, with conversion to 2-stage revision if evidence of infection. Secondly, appropriate preoperative planning and the presence of implant combinations and other surgical adjuncts such as bone graft and artificial augments to avoid compromise intraoperatively. Thirdly, the implant fixation and joint should both anticipate long term stability at the completion of the case. It is appropriate to accept increased level of constraint rather than instability. Postoperatively, rehabilitation is performed as per primary TKA, with consideration of weight bearing status variability based on grafts used. Finally, given the complexity of the surgical procedure involved in RTKA, consideration should be made to refer complex cases to RTKA subspecialist surgeons with a high volume of RTKAs performed and an experienced surgical team. Centralisation likely improves patient outcomes both short and long term.

Unfortunately, there is little opportunity pre-operatively to address modifiable patient factors and thereby improve postoperative outcomes. The results of this study demonstrated no statistically significant difference in modifiable factors (weight, BMI) and postoperative outcomes (OKS, ROM). Instead, this research provides insight into the likely outcomes postoperatively given the patient's preoperative variables, such as pre-operative ROM and number of previous RTKA surgeries. This research also helps inform clinicians and therefore guide patients in their expectations of postoperative outcomes.

This study has a number of limitations. Selection bias is present due to the nature of this study, with all patients receiving care by an experienced arthroplasty surgeon, by a surgical and perioperative team with minimal variation of members and established practices, and the use of a prosthesis which has demonstrated good results and low revision rate over long term follow up.(6) This combination of factors is likely to contribute to successful outcomes and therefore these findings cannot be applied to all patients and surgical settings.

Patient range of motion measurements were retrieved from orthopaedic follow up records, which were retrospectively reviewed. We therefore cannot guarantee that patient ROM remains unchanged during the period from 1 year postoperatively to the time of telephone assessment. Current ROM may give better insight into this outcome's effect on patient satisfaction, however we consider the change in ROM after 1 year postoperatively to be minimal in most patients.(136, 138) The absence of current radiographic investigation is a limitation which was considered at the time of study design. Unfortunately, we are unable to report on the classification of bone defects within this cohort. However, the use of augments to address bone defects and obtain zonal fixation at the time of RTKA was performed as required on an individual patient basis.

4.7 **Conclusion**:

RTKA in this cohort resulted in a statistically and clinically significant improvement in ROM, and a high OKS. The majority of patients (85%) were satisfied with their RTKA outcome, and a failure rate of 6.5% was found over a long follow up period (mean 6.5 years). There was a low rate of postoperative complications and readmissions.

Patients with a lower pre-operative ROM or increased number of previous RTKA procedures are more likely to require greater constraint implants, which contributes to a longer surgical time. Pre-operative ROM correlates with post-operative ROM, and use of a hinged implant results in lower OKS postoperatively.

While RTKA is a challenging and complex aspect of arthroplasty surgery, high patient satisfaction and good functional outcomes can be achieved in the majority of patients.

CHAPTER 5: ASSESSMENT OF PATIENT SATISFACTION FOLLOWING REVISION TOTAL KNEE ARTHROPLASTY

Abstract

Introduction / Background:

Previous published literature on patient satisfaction after revision total knee arthroplasty (RTKA) is limited, and results in difficulty for clinicians to explain and justify the likely outcomes for a patient considering RTKA surgery. This has implications on the provision of informed consent, as well as appropriately managing patient expectations.

We aim to report the first mid to long-term patient satisfaction outcomes following RTKA by a single surgeon, using a single prosthesis, at a single institution.

Methods:

Patient satisfaction was assessed by a structured telephone assessment questionnaire. Inclusion criteria were RTKA (Major) performed by Dr Ray Randle (RR), PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA. Patients were excluded if they had received a subsequent revision by a different surgeon.

Patient satisfaction was primarily determined by patient response to the question “Would you have the revision total knee arthroplasty again?”. Secondary assessment of patient satisfaction was assessed by a patient-rated score of satisfaction, from 1 (very dissatisfied) to 10 (very satisfied), and completion of the Mahomed Satisfaction Scale. Independent variables were obtained by chart review and subsequently assessed for significant impact on postoperative outcome.

Results:

202 RTKAs were performed in 178 patients between 2004 and 2015 inclusive. 54 patients were deceased, uncontactable, excluded, or declined participation.

This resulted in 124 patients (143 RTKAs) completing satisfaction assessment.

85% of patients would have the RTKA again. 8% of patients were unsure, 7% would not. Satisfaction score on a scale of 1 (very dissatisfied) to 10 (very satisfied) demonstrated a mean score was 8.17 (range 1-10), with 74% of patients scoring 8 or above, and 35% of patients scoring 10. The Mahomed Satisfaction Scale outcomes demonstrated a mean score of 87.7.

Statistical analysis demonstrated a statistically significant difference between satisfied and dissatisfied groups when comparing secondary satisfaction assessment methods ($p<0.001$). Secondary outcome measurements also correlated well with each other (Spearman's rho 0.75, $p<0.001$).
Statistically significant differences were found for OKS ($p<0.001$), pre-operative ROM ($p=0.001$) and postoperative ROM ($p= 0.039$) between satisfied and dissatisfied groups. Binomial logistic regression demonstrated statistical significance of OKS, BMI, and surgical time as predictors of postoperative satisfaction.

Conclusion:
Our results demonstrate a high patient satisfaction rate following RTKA, utilising simple and reliable outcome measurement tools. We found a strong correlation between methods of assessment, and correlation between satisfaction and functional outcomes. We believe that patient satisfaction is both multifactorial and difficult to predict preoperatively, with patient expectations being an important aspect of preoperative counselling.
These results contribute to the understanding of satisfaction outcomes in RTKA patients, which may assist in appropriately informing patients of expected post-operative outcomes

5.1 Introduction:

Patient satisfaction is becoming an increasingly important outcome measure of healthcare quality.(133, 192) Despite investigation into satisfaction after total knee arthroplasty (TKA), there is no gold standard or consensus regarding evaluation tools.(193)

Previous published literature on patient satisfaction after revision total knee arthroplasty (RTKA) is limited by short follow up periods, small patient cohorts, confounders such as multiple surgeons, prostheses and hospitals, and/or poorly described satisfaction assessment tools.
The paucity of published literature results in difficulty for clinicians to explain and justify the likely outcomes for a patient considering RTKA surgery. This has implications on the provision of informed consent, as well as appropriately managing patient expectations.

We aim to report the first mid to long-term patient satisfaction outcomes following RTKA by a single surgeon, using a single prosthesis, at a single institution.
We secondarily aim to report on identifiable factors which contribute to patient satisfaction following RTKA.
The methods of assessment utilised to assess patient satisfaction were identified through literature review as validated, reproducible, simple for the patient to understand, had minimal completion time, and able to be completed without a clinical examination.

Research questions:

1. In this cohort of RTKA patients, does patient rated score of 1-10 and/or MSS demonstrate a difference between satisfied and dissatisfied groups?

2. In this cohort of RTKA patients, is there a significant difference in OKS and ROM (preoperatively and postoperatively) between satisfied and dissatisfied patient groups? Does OKS correlate with score 1-10 and/or MSS?

3. In this cohort of RTKA patients, what factors (patient characteristics, preoperative, intraoperative, postoperative) may predict satisfaction?

Hypotheses:

We hypothesise that patient reported numerical score (Score 1-10) and Mohamed Satisfaction Scale (MSS) will demonstrate significant difference between satisfied and dissatisfied patient groups.

We hypothesise that ROM and OKS will have statistically significant difference between satisfied and dissatisfied groups, and OKS will correlate with Score 1-10 and MSS.

We hypothesis that patient satisfaction will be influenced by patient characteristics, preoperative variables, intraoperative variables, perioperative variables, postoperative outcomes, and postoperative complications.

5.2 Methods:

Ethical approval was obtained from institutional HREC (BUHREC approval number: 0000015604). Patients were identified through operative and booking records. Patients were contacted by telephone to obtain consent and completion of a structured assessment questionnaire, including satisfaction outcome measures and Oxford Knee Score. A chart review of hospital and orthopaedic documentation was then conducted to identify other key data.

Inclusion criteria were: Revision TKA (Major) performed by RR, PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA. Patients were excluded if they had received a subsequent revision by a different surgeon, as the patient's current satisfaction cannot be determined of an implant that is no longer in situ.

Patient satisfaction was primarily determined by patient response to the question "Would you have the revision total knee arthroplasty again?". Patients responses were grouped into 3 categories: Yes, unsure, or no.
Secondary assessment of patient satisfaction was assessed by a patient-rated score of satisfaction, from 1 (very dissatisfied) to 10 (very satisfied), and completion of the Mahomed Satisfaction Scale.(133)

Patients' expectations were discussed prior to RTKA surgery to inform the patients of their expected outcomes. Patients were informed that the expected outcomes post-RTKA would be decreased range of motion and power of the knee and surrounding musculature. The important risks discussed included infection and venous thromboembolism. The patients age and other characteristics were considered and discussed to establish a shared understanding of realistic goals.

5.3 Analysis techniques:

Assessment of normality was performed for data, using visual (normal Q-Q plot) and statistical (Shapiro-Wilk) methods.

Mann-Whitney testing was performed to assess for statistically significant difference in Score 1-10 and MSS between satisfied and dissatisfied groups due to the non-parametric nature of data.
Spearman's rho Correlation Coefficient was determined to assess correlation between Score 1-10 and MSS.

Mann-Whitney testing was performed to assess for differences in OKS and ROM between satisfied and dissatisfied groups. Spearman Correlation Coefficient testing was used to assess for correlation between OKS and secondary satisfaction measurements (score 1-10, MSS).

Binary logistic regression was used to assess for statistical significance of independent variables as predictors of the dependent variable of 'RTKA Again' outcome. Forward stepwise modelling was utilised to determine statistical significance of variables. Backwards stepwise elimination modelling was used to determine the order of importance of contributing variables.

5.4 Results:

202 RTKAs were performed in 178 patients between 2004 and 2015 inclusive. 27 patients (29 RTKAs) were deceased at time of review, 14 patients (16 RTKAs) were unable to be contacted, and 4 patients (4 RTKAs) declined to participate. 133 patients (153 RTKAs) completed telephone assessment, of which 9 patients (10 RTKAs) were excluded due to further revision by another surgeon (2 patients, 2 RTKAs) or revision by RR within the last 2 years (7 patients, 8 RTKAs). This resulted in 124 patients (143 RTKAs) for inclusion in satisfaction assessment.

The following data was collected and considered for patient satisfaction assessment:

Outcome / dependent variables –

Would you have your RTKA again? (Yes = 1, Unsure = 2, No = 3). This data was subsequently modified to binary outcome for statistical analysis.
Patient reported score (1-10)
Mahomed Satisfaction Scale score

Independent variables –

Patient characteristics: Gender, age, Age at time of RTKA operation

Pre-operative assessment: Patient weight, Patient BMI, Primary TKA Cause of Failure, Pre RTKA ROM

Intraoperative assessment: Prosthesis type (CR, PS, TC3, Hinge), Surgical time

Perioperative assessment: Blood transfusion required post-operatively, Duration of hospital stay total

Post-operative outcomes assessment: Oxford Knee Score (OKS), 3 months post RTKA ROM, 1 year post RTKA ROM

Postoperative complication assessment: Readmission within 90 days for RTKA related cause, Post-operative complication

Gender (% Male)	57% (n=71)
Time since RTKA	6.5 years (range 2-13 years)
Age at time of review	74.8 years (range 49-98)
Age at time or RTKA	68.3 years (range 45-90)
Age at time of primary TKA	60.1 years (range 32-86)
Mean weight at time of surgery	84.4 kgs (range 50–130)
Mean BMI at time of surgery	29.9 (range 19-46)
ASA score	2.4 (range 1-4)
Diabetic	14%
smokers	5% current, 32% past, 63% never
Blood transfusion required post operatively	15%
Duration of hospital stay	Mean 7.6 days, (range 3-42)
Readmission within 30 days	2
Postoperative complication	21 (9 patients requiring MUA, 6 superficial SSI, 2 deep infections, 1 pain, 1 wound dehiscence post fall, 1 haemarthrosis, 1 pulmonary embolism)
Pre-op albumin	Mean 43.6, (range 31-56)
Primary TKA surgeon	73 = RR, 70 = other surgeon
Reason for primary TKA	140 OA, 1 RA, 1 juvenile arthritis, 1 trauma
Number of prior revisions	Mean 0.22, range (0-4)

Table 8 - Patient demographics and post-operative details.

Normality of dependent outcome variables was assessed using visual (Normal Q-Q plots) and statistical (Shapiro-Wilk) methods.

Normally distributed data was found for variables of patient age, Age at RTKA, and Surgical time.

Non-normally distributed data was found for variables of Score 1-10, MSS, OKS, Time since RTKA, Age at time of primary TKA, Pre RTKA ROM, 3/12 ROM, 1 year ROM, Change in ROM, Duration of hospital stay, Post op Haemoglobin, Weight, and BMI.

Satisfaction Outcomes:

Patients were given 3 options for overall satisfaction assessment, “would you have RTKA again?”, Yes, unsure, or no. 85% of patients (n=121) stated that they would have the RTKA again. 8% of patients (n=12) were unsure, 7% (n=10) stated no. We deemed a response of “Unsure” to fall within the unsatisfied category for analysis.
Secondary outcome measurements for satisfaction also demonstrated a satisfied cohort. Satisfaction score on a scale of 1 (very dissatisfied) to 10 (very satisfied) demonstrated a mean score was 8.17 (range 1-10), 74% of patients (n=106) scoring 8 or above, and 35% of patients (n=50) scoring 10.
The Mahomed Satisfaction Scale outcomes demonstrated a mean score of 87.7 (range 31.25-100). 83.9% of patients (n=120) scored 75 or above, 46.2% of patients (n=66) scored 100.

Comparison of assessment methods:

Statistical analysis demonstrated a statistically significant difference between satisfied and dissatisfied groups when comparing secondary satisfaction assessment methods. Mann-Whitney U test demonstrated statistical significance for both ‘score 1-10’ and ‘MSS’ outcomes. Secondary outcome measurements also correlated well with each other (Spearman’s rho 0.74, p<0.001).

	Satisfied (n=121)	Dissatisfied (n=22)	
Score 1-10	8.5	6.0	p <0.001, 95% CI 1.7 - 3.3
MSS	91.7	65.6	p <0.001, 95% CI 20.3 - 31.8

Table 9 – Comparison of satisfaction assessment methods

Oxford Knee Score (OKS), preoperative ROM and postoperative ROM demonstrated statistically and clinically significant differences between satisfied and dissatisfied groups using the Mann-Whitney U test. The whole cohort mean OKS was 39.25 (range 14-48), mean preoperative ROM 100 degrees, mean 1-year postoperative ROM 112 degrees. The

minimum clinically important difference in ROM post TKA is reported as 5°.(189) The minimum clinically important difference in OKS post-TKA is reported as 5 points.(131, 191)

OKS strongly correlated with score 1-10 (Spearman's rho 0.566, p<0.001) and very strongly correlated with MSS (Spearman's rho 0.729, p<0.001).

	Total (n=143)	Satisfied (n=121)	Dissatisfied (n=22)	
OKS	39.25	40.8	30.3	P= <0.001, 95% CI 7.6 - 13.5
Pre-op ROM	100	104	80	P= 0.001, 95% CI 12.9 - 34.4
Post-op ROM	112	114	105	P= 0.039, 95% CI 1.5 - 15.1

Table 10 – Functional results

Assessment of predictor variables on satisfaction outcome

Binomial logistical regression analysis was utilised to identify factors which contributed to satisfaction in this patient cohort.
The dependent variable used was patient satisfaction, defined by patient response to "Would you have your RTKA again?".
All independent variables which were considered potential impacting factors on satisfaction were assessed, including:

Gender, Patient age, Age at time of RTKA operation, Patient weight, Patient BMI, Primary TKA Cause of Failure, Pre RTKA ROM, Prosthesis type (CR = 1, PS = 2, TC3 = 3, Hinge = 4), Surgical time, Blood transfusion required post-operatively, Duration of hospital stay total, Oxford Knee Score (OKS), 3/12 (3 months) post RTKA ROM total, 1 year post RTKA ROM total, Change in ROM (1 year postoperative minus pre-operative), Readmission within 90 days for RTKA related cause, Post-operative complication.

A Forward stepwise selection model of binary logistic regression was used to identify independent variables with significance on satisfaction as the dependent variable. Data analysis was firstly performed with a Probability of entry value of p=0.05, and then repeated with a value of p=0.10. While we acknowledge the more traditional approach of p=0.05, p=0.10 was deemed more appropriate to achieve the goal of this analysis. We sought to minimise the likelihood of failing to identify potentially significant predictor variables. The Forward stepwise (Likelihood Ratio) modelling was deemed most appropriate method of regression modelling for our analysis.

Initial analysis prior to application of the model demonstrated a number of statistically significant variables, namely OKS (p<0.001), Pre-RTKA ROM (p<0.001), 3 month ROM (p= 0.032), 1 year ROM (p=0.021), Change in ROM (p=0.001), and implant type (p=0.022).

Forward stepwise LR modelling with Probability for entry 0.05, Probability for removal 0.1, CI for exp(B) of 95%, Classification cut off 0.5
Identified OKS as a statistically significant variable. No further statistically significant variables were identified in subsequent steps of analysis.

Forward stepwise LR modelling with Probability for entry 0.10, Probability for removal 0.1, CI for exp(B) of 95%, Classification cut off 0.5
resulted in the identification of 3 significant predictor variables: OKS, BMI, and surgical time.
Forward stepwise variable selection using a Wald model with Probability for entry of 0.10 demonstrated the same results.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	77.635[a]	.245	.405
2	73.921[a]	.268	.443
3	70.015[a]	.291	.482

Classification Table[a]

			Predicted		
			RTKA again binary		Percentage
	Observed		1	2	Correct
Step 1	RTKA again binary	1	95	4	96.0
		2	13	8	38.1
	Overall Percentage				85.8
Step 2	RTKA again binary	1	94	5	94.9
		2	14	7	33.3
	Overall Percentage				84.2
Step 3	RTKA again binary	1	96	3	97.0
		2	10	11	52.4
	Overall Percentage				89.2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	OKS	-.200	.043	21.478	1	.000	.818
	Constant	5.714	1.520	14.125	1	.000	303.181
Step 2[b]	OKS	-.215	.046	21.416	1	.000	.807
	Patient BMI	-.126	.068	3.436	1	.064	.882
	Constant	9.909	2.848	12.102	1	.001	20100.592
Step 3[c]	OKS	-.228	.050	20.965	1	.000	.796
	Patient BMI	-.156	.074	4.442	1	.035	.856
	Surgical Time	.018	.009	3.836	1	.050	1.018
	Constant	8.536	3.065	7.754	1	.005	5093.994

a. Variable(s) entered on step 1: OKS.

b. Variable(s) entered on step 2: Patient BMI.

c. Variable(s) entered on step 3: Surgical Time.

Table 11 – Statistical Analysis (5)

An automated Backwards stepwise elimination (LR) binomial logistic regression model was then used to determine the order of importance of independent variables contributing to satisfaction. This model was constructed with the parameters of 0.05 probability for entry, 0.20 probability for removal, 95% CI for exp(B), classification cut-off 0.5. These parameters were chosen to most accurately identify significant variables, and minimise the likelihood of missing significant variables.
Statistically significant variables found were identical to previous forward stepwise logistic regression analysis.

At the final step of the applied model (Step 14), remaining variables included OKS (p= <0.001), BMI (p=0.035), Surgical time (p= 0.050). These results demonstrated an increased satisfaction with increased OKS, increased BMI, and shorter surgical time.

Variables in the Equation

								95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 14	OKS	-.228	.050	20.965	1	.000	.796	.723	.878
	Patient BMI	-.156	.074	4.442	1	.035	.856	.741	.989
	Surgical Time	.018	.009	3.836	1	.050	1.018	1.000	1.037
	Constant	8.536	3.065	7.754	1	.005	5093.994		

Table 12 – Statistical Analysis (6)

Using this model, we can determine the ranking of importance of variables influencing on patient satisfaction. These include (in descending order of significance):

1. Oxford knee score
2. Patient BMI
3. Surgical time
4. Gender

5. Pre-RTKA ROM
6. 3 Month ROM
7. Implant type
8. Cause of failure / Reason for revision
9. Readmission within 3 months
10. 1 Year ROM
11. Post operative complication
12. Age
13. Weight
14. Blood transfusion required
15. Duration of hospital stay
16. Time since RTKA operation

5.5 Discussion:

Patient satisfaction is becoming an increasingly important outcome measure of healthcare quality.(133, 192) Despite investigation into satisfaction after primary TKA, there is no gold standard or consensus regarding evaluation tools.(193)
Despite inconsistent methods of assessing patient satisfaction between authors, a satisfaction rate of approximately 80% is reported for their respective cohorts.(7, 194-196) Bullens et al reported a mean satisfaction visual analogue scale (VAS) of 80/100, with 68% of patients reporting a VAS above 80.(194) Robertsson et al identified a satisfaction rate of 81% of 27,372 Swedish patients including primary and revision TKA.(196)
Noble et al demonstrated a satisfaction rate of 75% of patients after primary TKA. They noted that satisfaction following TKA is primarily determined by patient expectations, rather than absolute level of function.(195) Our cohort demonstrates a similarly high patient satisfaction rate for RTKA from all causes of revision.

Similar to TKA, RTKA patient satisfaction assessment demonstrates varied methods of assessment between authors. While RTKA rate is increasing(6), there remains limited published data on assessment of patient satisfaction postoperatively.
Barrack et al(117) report outcomes following 125 RTKAs with mean follow up of 36 months. Patient satisfaction assessment was not clearly detailed, however the authors report 11% of patients dissatisfied, with no report of neutral or partially satisfied patients.

They found no difference in satisfaction between septic and aseptic groups.
Wang et al(12) report a satisfaction rate of 85% following RTKA in 48 patients, with no difference between septic and aseptic reason for revision. The authors did not describe the methods used to assess patient satisfaction in their cohort.
Robertsson et al report a rate of 59% satisfied or very satisfied in RTKA patients, in a cohort of 2097 Swedish patients.(196)
Difference in opinion and outcome exists between authors regarding comparison of outcomes between primary TKA and RTKA.(10, 11, 196) This limits the appropriateness of primary TKA outcomes in guiding patient and clinician expectations.
The paucity of published literature of RTKA satisfaction results in difficulty for clinicians to explain the likely outcomes for a patient considering revision arthroplasty surgery. This has implications on the provision of informed consent, as well as appropriately managing patient expectations.

We identified methods of assessment which were validated, reproducible, simple for the patient to understand, quick, and able to be completed without a clinical examination, and applied these to the RTKA population.
Our primary question to determine patient satisfaction, “would you have RTKA again” was structured specifically to reflect all aspects of patient satisfaction in a single outcome response. We believe that patient satisfaction postoperatively is multifactorial, and includes a combination of: pre-operative pain and function, the process of undergoing operative intervention including the rehabilitation and recovery process with a strong focus on pain experienced, time spent in hospital as well as at decreased level of function, financial costs involved, postoperative level of pain and function, the emotional, psychological and social impact of further operative intervention, as well as patient specific personal characteristics, which are difficult to define or quantify.
The question allows for the patient to give an overall, retrospective, subjective opinion regarding RTKA surgery, and if they felt it was worthwhile for them as an individual. Ultimately, a patient will only be satisfied if they believe the many negative aspects of revision surgery are outweighed by the benefits.
Response to this question was the choice of 3 options, Yes, unsure, or no, yet the unsure and no responses were deemed to be dissatisfied. We believe that assessing outcomes in this way will result in a conservative estimate of patient satisfaction scores, which is an important element in managing expectations for future patients considering RTKA.

Patient rated satisfaction score on a scale of 1 (very dissatisfied) to 10 (very satisfied) was utilised as a simple and quick secondary outcome measure.
Use of the Mahomed Satisfaction Scale was chosen due to it being designed specifically to assess patient satisfaction following total joint arthroplasty.[133, 134] We defined a score of 75 or above as satisfied, as this corresponds to the patient being 'somewhat satisfied', on average, across all domains measured. A score of 100 demonstrates patients to be 'very satisfied' in all domains.(132)

The comparison of measures of satisfaction was performed to determine the clinical utility of each test and need for multiple testing techniques to assess different aspects of satisfaction (ie overall satisfaction, function, pain).
We propose that if these outcome scores correlate strongly and with statistical significance, then fewer tests could be used to assess the multi-dimensional nature of satisfaction. However, if a strong, statistically significant correlation was not found, then a combination of assessment tools remains best clinical practice.
Analysis of these variables in this cohort demonstrated a strong, statistically significant correlation between satisfaction and functional variables. Therefore, we suggest that multiple outcomes measures are not necessary to assess patient satisfaction. The choice of particular outcome measure(s) can be determined by the individual surgeon based on their personal preference.

The Oxford Knee Score (OKS) was chosen as the functional outcome measurement during telephone assessment due to its short completion time, simplicity and ability to be completed verbally. The OKS has demonstrated adequate internal consistency and test-retest reliability, and shows good correlation with knee-specific and general health questionnaires. The OKS is reliable, valid and responsive to change following TKA, and therefore is considered to be a useful clinical tool.(127-130)
This cohort demonstrated a statistically and clinically significant difference in ROM preoperatively and postoperatively between the satisfied and dissatisfied groups. While we are unable to suggest a specific ROM measurement which will improve patient satisfaction postoperatively, we do suggest that adequate ROM to allow independent activities of daily living likely contributes to satisfaction. The required ROM to successfully complete activities of daily living is variable between patients and therefore no broad generalisations

can be made at this stage. Further research on the impact of ROM following RTKA is required.

This study has a number of limitations. Selection bias is present due to nature of this study, with all patients receiving care by an experienced arthroplasty surgeon, by a surgical and perioperative team with minimal variation of members and established practices, in a private healthcare facility, and the use of a prosthesis which has demonstrated good results and low revision rate over long term follow up.(6) This combination of factors is likely to contribute to successful outcomes and therefore these findings cannot be applied to all patients and surgical settings.
Patient range of motion measurements were retrieved from orthopaedic follow up records, which were retrospectively reviewed. We therefore cannot guarantee that patient ROM remains unchanged during the period from 1 year postoperatively to the time of satisfaction assessment. Current ROM may give better insight into this outcome's effect on patient satisfaction, however we consider the change in ROM after 1 year postoperatively to be minimal in most patients.
The lack of current clinical assessment and radiographic investigation are shortcomings which were considered at the time of study design. We sought to identify methods of assessment which could be reproduced by other surgeons without requiring patients to undergo the process and cost involved with attending their surgeon's outpatient clinic and/or obtaining radiographs. However, we would encourage patients to undergo postoperative review as deemed appropriate by their treating surgeon, as well as further review if patients were identified to have low satisfaction or functional scores.

We were unable to obtain satisfaction scores from 54 patients (59 RTKAs) due to death, loss of follow up, exclusion, or declining participation. This is an unfortunate reality of long term follow up studies, particularly with a significant proportion of patients being elderly. The above limitations could be improved through prospectively recruiting patients into a long-term outcomes study, with clinical and radiographic assessment at scheduled time intervals postoperatively. A multicentre trial including multiple surgeons and different prostheses used would enable the development of outcomes with a great external validity.

This research contributes significantly to current literature and understanding regarding patient satisfaction following RTKA. The results, while not applicable to all patients or

surgical settings, contribute to the establishment of realistic outcomes which can be discussed with patients to establish a shared understanding of likely outcomes postoperatively.

This study is the first which we are aware of to utilise multiple outcome measurements for patient satisfaction in the RTKA cohort. We found a strong correlation between outcome measures, enabling clinicians to utilise one or more of these measurement tools in assessing their patients' satisfaction.

This study is the largest which we are aware of identifying a patient cohort not impacted by multiple surgeons, prostheses or surgical facilities. With mid to long term outcomes and a large cohort, we believe that our results are of a high quality and will be beneficial to the international orthopaedic community in developing a greater understanding of patient satisfaction following RTKA.

5.6 Conclusion:

Our results demonstrate a high patient satisfaction rate following RTKA, utilising simple and reliable outcome measurement tools. We found a strong correlation between methods of assessment, and correlation between satisfaction and functional outcomes. We believe that patient satisfaction is both multifactorial and difficult to predict preoperatively, with function and patient expectations being an important aspect of preoperative counselling. Statistically significant predictors of patient satisfaction found within this cohort include Oxford Knee score, BMI, and surgical time.

These results contribute to the understanding of satisfaction outcomes in RTKA patients, which may assist in appropriately informing patients of expected post-operative outcomes.

CHAPTER 6: "THE LIVED EXPERIENCE" – A PATIENT PERSPECTIVE OF REVISION TOTAL KNEE ARTHROPLASTY

Abstract

Introduction / Background:

Orthopaedic research into outcomes following Revision Total Knee Arthroplasty (RTKA) has traditionally been focused on quantitative outcome measures. We sought to investigate the patient perspective of this surgical procedure, to provide clinicians with a greater insight into the factors surrounding orthopaedic care which most significantly impacted the patient. We aim to report patient opinion of the RTKA process at mid to long term follow up.

Understanding the experience of this cohort of patients will enable clinicians to gain insight into areas for specific discussion with future patients. While every patient and situation is different, common themes should be discussed to assist in developing a shared understanding of RTKA, preoperatively and beyond.

Methods:

Ethical approval was obtained from institutional HREC. Inclusion criteria were: Revision Total Knee Arthroplasty, performed by the senior author (RR), PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA. Patients were identified through operative and booking records and contacted by telephone to obtain consent and completion of a structured assessment questionnaire, including an opportunity for non-directed patient comments.

Comments were recorded at the time of assessment and subsequently reviewed using a combination of thematic and content analysis, following completion of data collection.

Results:

102 patients provided comments. The overall impression of comments were 88 positive, 8 neutral, 6 negative. 7 common themes were identified during analysis, including: the surgeon(s) involved in patient care, preoperative condition and change in condition following RTKA, postoperative level of function and ability to complete specific activities, impact of surgery on pain and management of pain in perioperative period, rehabilitation and postoperative recovery, other issues impacting patient quality of life, and overall patient satisfaction.

Conclusion:

The impact of RTKA surgery on a person is not easily quantified. As an individual, the patient is impacted in a myriad of ways, encompassing all aspects of a bio-psycho-social approach to health care. These factors, combined with the vast number of other influencing factors, contribute to form the patient's 'lived experience' of RTKA.
Analysis of patient opinion and experience is a valuable addition to traditional assessment of outcomes in medicine, providing us with a basis for thought and discussion into the 'lived experience' for our patients now and into the future.

6.1 Introduction:

Orthopaedic research into outcomes following Revision Total Knee Arthroplasty (RTKA) has traditionally been focused on quantitative outcome measures. We sought to investigate the patient perspective of this surgical procedure, to provide clinicians with a greater insight into the factors surrounding orthopaedic care which most significantly impacted the patient.

A qualitative approach to patient experience following RTKA can reveal valuable insights not easily identified or understood from quantitative outcome measurement tools.(197)
The use of a qualitative approach has been described to offer 'rich and compelling insights into the real worlds, experiences, and perspectives of patients and health care professionals in ways that are completely different to, but also sometimes complimentary to, the knowledge we can obtain through quantitative methods.'(197)

We consider that for clinicians to best serve their patients; the concerns, fears, expectations and goals of the patient must be understood and discussed. Only with this knowledge can the doctor-patient relationship be patient-centred, holistic and focused on meeting the needs of the individual.
Understanding the experience of this cohort of patients will enable clinicians to gain insight into areas for specific discussion with future patients. While every patient and situation is different, common themes should be discussed to assist in developing a shared understanding of RTKA, preoperatively and beyond.

Research question:

In this RTKA cohort, what key features of the RTKA journey are described by patients as significant in their 'lived experience of RTKA'?

Hypothesis:

We hypothesise that patients will report common themes which are influential factors on their personal 'lived experience' of RTKA surgery.

6.2 Methods:

Ethical approval was obtained from institutional HREC (BUHREC approval number: 0000015604). Patients were identified through operative and booking records. Patients were contacted by telephone to obtain consent and for completion of a structured assessment questionnaire. Inclusion criteria were: Revision Total Knee Arthroplasty, performed by the senior author (RR), PFC (Depuy) prosthesis used, at John Flynn Private Hospital, with a minimum of 2 years since date of RTKA.

Patients were given the opportunity at time of telephone interview to give comments regarding their RTKA experience. All patients were asked to provide comments relating to their personal experience of RTKA. Patients were not guided regarding topics for discussion or themes to comment on, thereby allowing an unrestricted, multidimensional view of the patients' experience. The assessment of patient experience, including the length or interview, was directed by the patient.

All comments provided were recorded at the time of assessment and subsequently reviewed following completion of data collection. No patients who met inclusion criteria were excluded from providing comments. Patients were not limited in the length of comments provided. This approach is supported by other authors as an appropriate method of investigating and analysing patient experiences.(198)

The patient comments were reviewed and classified based on the primary themes, identified using a combination of thematic and content analysis approaches.(185)

The use of narrative, verbal and nonverbal descriptions of personal experiences, and the thematic analysis of this information has been widely used to explore concepts of a qualitative nature.(198) The combination of frequency and conceptual analysis of patient

comments provides the opportunity for attention to the patient's comment as a whole, providing insight and understanding of the overall patient experience, before assessing subsections of patient comments as individual pieces of information.(199) The overall understanding of the individual's comments enables a reliable context for interpretation of themes within. It is for this reason that the combination of traditional qualitative methods was used in this analysis. This technique of analysis allows for the investigation of complex information which resists simple classification.(197)

Similar qualitative methods have been used to assess factors associated with primary TKA including patient decision making(200), hospital experience(201), physical activity after TKA(202), and the impact of postoperative complications(203). A recent systematic review of qualitative research in TKA patients demonstrated a paucity of focused assessment of patient perspective in this cohort.(204) Literature search did not identify any qualitative assessment of patients following RTKA procedures. With no previous research of this type in the RTKA cohort, this method of assessment was based on techniques used by previous authors investigating similar topics.

Validation / verification strategies were adopted to support the methodology and reporting of results. The framework described by Morse et al has been used as a guide in defining features consistent with valid qualitative research.(205)
Methodological coherence is demonstrated through the use of patient description of their personal experience, with no direction or guidance. The open-ended, unrestricted opportunity to describe their individual perspective enables assessment of all potential impacting factors. Analysis via thematic and content assessment, at the completion of data collection, was considered most appropriate for the obtained data.
Cohort sampling was of a high standard, with included patients all having personally experienced RTKA. The patient cohort could be expanded to include patients receiving care from other surgeons, however this was not appropriate for the current research project.
Collecting and analysing data concurrently was considered but not adopted in the study design. We believe that post hoc assessment of comments removes the potential for guidance of patients towards topics previously discussed by other patients.

Respondent validation was not performed, but could be considered for future research if the same or an expanded patient cohort was investigated. Triangulation techniques were not performed due to the study design.

6.3 Results and Discussion:

A total of 102 patients provided comments as a part of telephone assessment. 88 were considered to be positive comments, 8 were considered to be neutral, and 6 comments were considered to be negative.

7 common themes were identified during analysis:

- The surgeon – RR and other surgeons involved in patient care, both positive and negative comments.
- The patient's condition preoperatively and the change in outcome following RTKA.
- The level of function achieved postoperatively and specific activities that are important to the individual patient.
- The impact of surgery on pain, and the management of pain in the perioperative and postoperative periods.
- The rehabilitation process and postoperative recovery.
- Other issues impacting pain or function of the patient.
- The overall patient satisfaction.

<u>The Surgeon(s)</u> –

The patients in this study attach significance to the surgeons involved in their care. Other research supports this, and has demonstrated that better doctor-patient communication was associated with higher patient satisfaction.(206, 207)
The final outcome that the patient experiences is linked to the operation performed, the operative ability of the surgical team, and the surgeon(s) involved. However, there are other factors beyond the control of the surgical team which many patients are unaware of. This results in patients becoming polarised in opinion of the surgeon(s), either attributing praise and thanks for their satisfaction and successful outcome, or attributing blame for their pain and disability. In reality, many if not all RTKA procedures are heavily impacted

by uncontrollable factors, but in the patient's eyes, it is often the surgeon alone who influenced their current condition.(208)
The link between surgeon and outcome was clearly established in some patients' comments. They felt that their outcome was due to the surgeon alone, and they attributed gratitude or blame accordingly.

44 of the 102 patients gave comments regarding their surgeon(s). 29 were positive, 11 negative, and 4 drew comparison between surgeons. Of the patients who made positive comments, the surgeon was the primary theme in their response in 20 patients. 5 of the 11 negative comments were the primary theme of the patient responses.

The positive comments made regarding the surgeon(s) demonstrates the gratitude which many patients have for the care they received.

"Dr Randle did a fantastic job, he did everything right."
"Dr Randle is exceptional. I'm doing well."
"Keep up the good work Dr Randle."
"Thank you Dr Randle for your support during a challenging time for me."

Patients also express this gratitude and satisfaction in their personal recommendation to others of the surgeon involved. Word of mouth referral has been shown to significantly impact a patient's choice of surgeon.(209)

"I would recommend Dr Randle to anyone."
"I'm very happy and no one else is going anywhere near my knees with a knife."
"I wouldn't go to anyone else. Dr Randle has done a wonderful job."
"I'd go back to Dr Randle, he's the best."

In contrast to the positive comments regarding their surgeon, some patients commented on their negative opinion of previous surgeons. A poor outcome following an operation, which subsequently requires revision, is perceived by many patients as a failure of the primary surgeon. Previous authors have described the patients' belief that 'anything less than a perfect outcome is a failure'.(210) Factors outside of the surgeons' control are not acknowledged or considered by many patients. The negative comments made and the

opinions held by patients cannot be easily supported or refuted. However, irrespective of the veracity, patient perception and its link to satisfaction is an important aspect of care provision now and into the future.

The names of other surgeons have been removed in the interest of confidentiality and professionalism.

"First operation by Dr _____, I was terrible afterwards"
"Primary done by Dr _____, pain and instability afterwards."
"Primary by Dr _____ was falling apart. No troubles with the revision knee at all"
"I was unable to walk at all after the first operation. Dr _____ was terrible."

Interestingly, in the setting of RTKA, there may have been multiple surgeons involved in the patient's care. This allows patients to identify an individual as the cause of their complaints, and, if they had a successful revision outcome, another surgeon as the solution to their problems. Some patients also identify their condition prior to RTKA surgery, and contrast this with their post-RTKA outcomes. For these patients, the focus is not on their condition prior to any surgical intervention, but rather the impact of revision surgery to address a poor outcome after primary (or subsequent revision) TKA.

"Dr Randle did a great job. The damage was already done."
"Terribly disappointed with first operation. Dr Randle is brilliant. Improved with revision operation."
"Very happy with second operation, but not a great final result because of how bad after the first operation. Dr Randle was excellent."
"I was shocking before Dr Randle's revision operation. Improved out of sight by the revision. I wish I went to Dr Randle for the first operation."

<u>Preoperative condition and change postoperatively</u> –

The preoperative condition of the patient and their primary TKA outcome was commented on by a number of patients. This preoperative condition is a significant impacting factor for the patient in 2 separate ways.

Firstly, the preoperative condition must be troublesome enough for the patient to justify undergoing further operative intervention. The process of knee replacement surgery with the associated anaesthetic, pain, physiotherapy, rehabilitation and other challenges has previously been experienced by these patients, and therefore the decision to undergo this again is not something entered into without careful consideration.

Secondly, the preoperative condition determines the baseline from which we can attempt to measure a change and therefore gauge success from a revision procedure.

Based on the above considerations, discussion with the patient preoperatively to clearly quantify the patient's condition and limitations enables the appropriate management of expectations regarding postoperative outcomes. In a patient who has only minor difficulties or discomfort, a revision procedure may not be in the patient's best interest, and improvement may be minimal. However, in a patient with significant difficulties and / or pain, then a RTKA may provide a marked improvement for the patient and result in a highly satisfied patient.
A recent meta-analysis and systematic review demonstrated pre-operative pain to be a significant predictor of post-operative pain after primary TKA, suggesting that other factors may also impact the patient's ability to be pain-free postoperatively.(211) Previous authors have also described no significant change in reliance on mobility aids at 12 months post TKA.(212)

The patient comments reflect the issues preoperatively which resulted in consideration of the revision procedure. Some patients were specific in the aspects of pain or function which they deemed warranted revision, while other patients commented in broader terms regarding their preoperative condition. 17 of 102 patients commented on their preoperative condition, which demonstrates the importance of this factor in pursuing further intervention.

"Horrible before the revision"

"Lots of trouble before the revision operation, constant pain. I would certainly do it again"

"My knee was terrible"

"I was shocking before Dr Randle's revision operation"

While patients may or may not have an accurate understanding of the underlying cause of failure, they are reliable in determining if their level of function and pain control is adequate. The use of layman's terms such as "terrible", "horrible" and "shocking" demonstrate the impact of the patient's condition on their health and wellbeing, and provide some insight into the dysfunction caused by a suboptimal outcome from a primary knee replacement procedure.

No patients commented on their preoperative condition as acceptable or manageable, instead, all patients had experienced a high level of pain or poor function and understood that a significant issue required intervention. Resulting from this, we can expect that patients would have a developed an understanding of the need for revision, as well as appropriately managed expectations and engagement in the RTKA process. From this point of preoperative dysfunction, the patient and surgeon together can aim towards improvement in symptoms and achieving acceptable postoperative outcomes.
For patients who may have developing problems with their knee replacement or are asymptomatic at the time of review, particular focus on discussion and developing a shared understanding of the options and recommendations is required. In this patient subgroup, a poor outcome postoperatively would likely result in a dissatisfied patient.

Improvement with RTKA –

The sought after outcome from a patient perspective following RTKA is to have experienced an improvement in pain and / or function in comparison to the preoperative condition. Change in outcome was commented on by a number of patients, supporting the idea that both the change in condition, as well as final outcome, are important factors in patient interpretation of success in RTKA. Improvement in knee function is associated with greater patient satisfaction following TKA(213).In patients with lower preoperative physical function prior to primary TKA, other authors have demonstrated that function and pain were not improved postoperatively to the level achieved by those with higher preoperative function.(214) Complicating this assessment is the inaccuracy of patient recollection of preoperative pain and function demonstrated in a TKA population.(215)

17 patients commented on their improvement with the RTKA procedure, 13 of these as their primary comments. In these patients, they perceive a successful outcome and therefore consider the process of RTKA worthwhile.

"I was stuffed prior to the revision operation. No problems with the revision knee at all"

"Dr Randle's revision operation made me much better"

"Great operation, I am significantly improved by the revision"

"Very good outcome, much better. I am very happy"

"Improved out of sight by the revision"

2 patients commented on their unchanged condition following RTKA.

"About the same as before the revision"

"Bad before, unchanged"

In these patients, the process of RTKA is likely not considered worthwhile or of significant benefit. The importance of appropriate discussion and developing a shared understanding preoperatively regarding likely postoperative outcomes is exemplified in this patient subgroup. Some patients will not perceive improvement following RTKA, and all patients must be aware of this reality. No patients commented on significant deterioration or worsening as a result of their RTKA procedure.

The impact of recall bias and other confounding factors on the perceived change following RTKA is likely to be a significant influencing factor on patient satisfaction and overall opinion of RTKA postoperatively. While understanding these factors may enable us to better quantify improvement and demonstrate the actual difference made by RTKA, the value to the individual patient is limited. Instead, it is the perception held by the patient, their level of satisfaction and their personal experience which determines the outcome for the individual. The use of quantitative assessment tools at multiple time points including preoperatively will enable clinicians to demonstrate to their patients the amount of improvement from preoperative condition, and should be considered as a part of routine practice.

Postoperative condition –

The long term functional outcome and ongoing level of pain experienced following a RTKA is an important factor in the patient's experience and satisfaction postoperatively. A patient who has a good result long term will likely be satisfied with the overall process to achieve their current outcome, which has been demonstrated in a primary TKA population.(195) Conversely, patients with ongoing issues or concerns are more likely to be dissatisfied or consider minimal benefit from the RTKA process. While comparison to preoperative condition and change from preoperative condition is important, the final result, experienced every day by the patient, determines the patient's ongoing experience and therefore is likely the most significant factor influencing the patient's opinion of RTKA.

Many patients commented on their successful outcome of RTKA, described by the patient regarding minimal or absence of pain, high level of function, or in broad terms of overall satisfaction.

"Doesn't stop me doing anything"
"People don't believe that I have had knee replacements"
"Excellent"
"My knee is like a 15-year old. Better than everyone else I know who has had a knee replacement"
"Good as gold"
"No troubles with the revision knee at all"

These comments demonstrate that the individual has experienced a positive outcome following their RTKA. The timing of these comments at a minimum of 2 years postoperatively enables us to gauge the likely ongoing level of function that the patient will experience. These patients have likely achieved a plateau of functional abilities and improvement, and will hopefully maintain their current condition into the future. Previous studies have demonstrated a gradual decline in overall functional scores following TKA over the long term, likely associated with general patient functional decline.(216, 217)

Not all patients describe a high quality functional outcome following RTKA. A number of patients expressed some dissatisfaction with a particular aspect of pain or function

following RTKA. While this may not significantly impact the overall satisfaction of the patient with the RTKA process, the specific areas of patient concern can guide us towards a better understanding of what outcomes patients may find most troublesome.

"I have difficulty with prolonged standing"
"It's sore after a long day of shopping"
"Stiffness is my main concern"
"The knee stiffens after immobility. I Can't stand for as long as I would like. I am unable to completely straighten"
"I need a walker to get around"

These patient comments demonstrate that for a significant number of patients, stiffness or lack of mobility at the knee is a concern. Stiffness is a known and discussed complication following any joint surgery, and is particularly relevant following multiple operations on a joint.(218) Range of motion to allow for completion of activities of daily living will vary between patients, as will their expectations of how much a knee should bend. The range of motion obtained postoperatively following RTKA has been previously described, with a successful outcome in the majority of patients. The patients' perception of stiffness or inadequate range of motion is likely based primarily on the expectation they have, which is impacted by a wide variety of sources and influences.

These comments demonstrate the importance of a shared understanding preoperatively, as well as ensuring ongoing expectation management of patients postoperatively. Unrealistic goals or inappropriate comparisons will negatively affect patient satisfaction, while well-managed patient expectations can result in a satisfied patient postoperatively, even if the obtained range of motion is not optimal.

Functional abilities and specific tasks –

Patients commented on their functional abilities and specific tasks which they can or cannot complete postoperatively. The presence or absence of function allows patients a tangible and easily comparable outcome regarding improvement from their RTKA operation.

The functional activities which patients commented on included employment, sports, mobility for recreation as well as for activities of daily living, social interactions, housework, and travel.

Employment –

Some patient's primary comments regarding their RTKA experience was to describe their ability to remain in the workforce postoperatively. For these patients, the RTKA operation was potentially a catalyst into forced retirement due to physical inability. Conversely, the successful outcome following RTKA has enabled these patients to continue in employment, which to them is more significant than other outcomes postoperatively. Previous research has demonstrated the importance of meaningful employment to individuals, impacting on depressive affect, personal competence and life-satisfaction.(219) Patient comments included:

"I'm a carpet layer, and still working".
"I'm back at work and the knee is no trouble".
"I work on an orchard every day".

The implications of forced unemployment on personal, social and financial aspects of a patients' life are significant.(220) Anecdotally, many patients delay primary TKA surgery until after retirement, due to fears of inability to return to work. Although patients who are undergoing TKA or RTKA prior to retirement age constitute only a small percentage of the TKA population, the impact of this decision should be strongly considered by all involved in patient care. In working age patients, those who are employed prior to TKA have a high rate of return to work postoperatively.(221, 222) The expectations that patients have about their ability to return to work postoperatively should be thoroughly explored, and the likely outcomes carefully discussed, prior to undertaking operative intervention.

Sports –

Many patients commented on their ability to return to sports which they enjoyed prior to undertaking TKA or RTKA surgery. These sporting pursuits are significant for the individual patient, and the ability to enjoy these pastimes provides the patients with great

satisfaction. Return to appropriate sport after knee arthroplasty is important to patients and supported by orthopaedic surgeons.(223, 224)

"I do cross-fit three times per week, and boxing twice per week. It feels like a normal knee"

"I exercise every day"

"I play 18 holes of golf most days"

"I'm training in the gym a few times per week"

"I go to the gym a couple of times a week. I push the knee pretty hard"

"I play lawn bowls most days"

"I'm back in the gym two or three times per week"

"I'm able to walk around the golf course. It is fantastic to be active again"

"I'm playing golf and the knee doesn't give me any trouble"

"I play bowls a few times per week"

"I play lawn bowls for three hours at a time without difficulty"

These comments also support the high level of function which can be achieved following RTKA surgery. Although difficult to quantify, the activities described by these patients would likely be considered moderate to high intensity by those of a similar age. In many patients, RTKA surgery should not be considered a catalyst to a sedentary lifestyle. Instead, it should be viewed as a means to regain or continue physical activity and maintain a healthy lifestyle.

Walking –

The simple task of walking independently is seen as a significant achievement for many patients following RTKA. Patients have identified the ability to walk independently as a significant achievement postoperatively, and use it as an indication of operative success.(225) Patients are encouraged to participate in walking (and other low impact activities) following knee arthroplasty to maintain physical fitness.(226) Previous studies have identified the importance of walking to patients and the high expectations that patients have of their walking ability postoperatively.(208)

While some patients participate in walking as a sporting or social activity(227), many are encouraged by their ability to complete activities of daily living which require adequate

mobility, such as shopping. Inability to mobilise independently would be a significant limitation on functional tasks and quality of life, and therefore this simple measure of achievement is an especially relevant one to this patient population.

"I walk 5 kilometres per day, I am very happy"
"I use a walking stick for balance only. Prior to the operation I was using 2 walking sticks, and a wheelchair for going more than a hundred metres"
"This procedure has given me trouble free mobility"
"People don't believe that I have had knee replacements. I walk an hour each day"
"I was unable to walk after the first operation. I am much improved by the revision"

Other activities of daily living –

There are a number of other activities or functional challenges which patients consider part of a normal life. These include housework, yard work, gardening, travel, and shopping.

"It's sore after a long day of shopping"
"It doesn't stop me from doing anything"
"I'm still social, I still get around"

Many patients feel that completion of housework and / or yard work is a necessary part of their daily lives. While they see the necessary nature of many tasks, some also find enjoyment and satisfaction in their completion. As such, the ability of a patient to return to being able to complete home or yard work is significant for the individual. Many patients self-report significantly increased in activities including housework and shopping following knee arthroplasty, despite no increase in objective measures.(228) Ongoing disability after RTKA is reported within the published literature.(229) The process of returning to being able to mow a lawn is described by 2 patients in our cohort. This can be a physically demanding process for individuals without significant musculoskeletal issues, and a return to this activity likely demonstrates a high level of function in these patients.

"I do everything around the house. I have been climbing ladders all week and its doing well"
"I was very stiff prior to the revision. I'm now mowing lawns for my neighbours"

"I garden. I am very active again"
"Now able to mow the lawn again"

The ability that a patient has to undertake overseas travel independently was described by a number of patients, and is reported in other patient populations as an important consideration.(230) Some patients see this task as the ultimate demonstration of their function, as it requires a high level of mobility, endurance and adaptability. To be able to complete overseas travel postoperatively, without significant issues or concerns provides patients with great satisfaction, and demonstrates to them that their operation has been a success.

"I've been travelling recently, we walked about 12 kilometres every day. It was great"
"I've been on overseas trips since, with no concerns or problems"

<u>Pain</u> –

Pain was a theme commented on by 13 patients in this cohort. A number of patients commented on the improvement that the RTKA procedure made to their pain. Primary TKA, despite being a procedure intended to address pain and function, still results in significant pain in a small percentage of patients postoperatively.(231) Other studies have demonstrated a significantly higher rate of moderate-severe pain after RTKA compared to primary TKA.(232)
RTKA can be performed for pain, with a surgically correctable cause identified preoperatively. While patients may not be aware of the underlying cause of their pain prior to RTKA, the relief of these symptoms is a significant improvement for the patient, and for many patients justifies the process of undergoing the revision surgical procedure.

"Previously (preoperatively) living on endone, I'm improved by the revision"
"Lots of trouble before the revision operation, I was in constant pain. I would certainly do it again"
"Lots of pain prior to the revision. More than happy"
"Primary gave me pain and instability. Much better after the revision operation"

Perioperatively, pain is a common and expected element of recovery.(233) Pain was described as a significant factor for 2 patients. In contrast to each other, these patients described a painless operation, or a very painful postoperative course. Although this was only a negative factor described in 1 patient, it does support the need for close observation, management and review of patients experiencing pain postoperatively.(234)

"I had severe postoperative pain"

From a positive point of view, the absence of significant pain postoperatively was an important factor for this patient.

"A painless operation"

Anecdotally, nearly all patients experience some degree of pain or discomfort postoperatively, which is to be expected following significant surgical intervention. This is able to be appropriately controlled in the majority of patients, and decreases significantly in the weeks postoperatively. Therefore, while patients should be made aware of the likely pain and discomfort they will experience, they should also be confident in the treating team's processes and abilities to manage pain beyond what is expected.

Current pain (or absence of pain) experienced by patients was described by 6 patients. 2 patients describe the absence of pain, providing a positive outcome and enabling greater function.

"Painless"

"Minimal or no pain"

4 patients describe ongoing pain associated with operative intervention. A combination of sources of pain are described, including pain preceding the RTKA operation or pain arising postoperatively. 1 patient commented specifically on the ongoing requirement of analgesia.

"Pain killers required to get me going in the morning."

"Dr Randle's revision was complicated by stem tip pain."

"I persevere through the pain."

"I have nerve pain, unchanged from prior to revision operation."

While ongoing pain following primary TKA or RTKA is a known and discussed risk of surgery,(233) most patients are satisfied with the pain relieving outcome of their surgery, as previously identified within this patient cohort. The development of new sources of pain, such as stem tip pain, is an unfortunate complication experienced by some patients. The requirement for ongoing regular analgesia in the long term postoperatively should raise concerns for other sources of pain or concerns with the knee replacement itself.(231) However, it is important that analgesia use is quantified and managed appropriately, given comorbidities and other patient factors. The appropriate use of analgesia regularly, while not ideal, does not necessarily indicate a poor overall outcome postoperatively.

Rehabilitation –

Postoperative rehabilitation following RTKA is a process which is integral to optimising function and facilitating completion of activities of daily living,(235) and is of particular importance to patients with slow progress or other limitations of mobility and function.(236) All patients within this cohort had previous personal experience with rehabilitation or physiotherapy of some sort due to their prior TKA procedures, and the importance of this process was understood and commented upon.
A number of patients reported their postoperative rehabilitation / physiotherapy process as a success, with many indicating that they continue to complete a structured program to maintain function. Patient understanding of this process is highlighted in the comments given, including:

"I didn't do my exercises properly"

"I do all my physio and exercises"

"I still go to the gym a few times per week to keep the knee strong"

No patients commented specifically on negative aspects of the rehabilitation process. Many patients within this cohort were offered an extended inpatient stay for physiotherapy and rehabilitation, which likely results in a positive opinion and the understood importance of this process. While some authors have determined little or no value of inpatient rehabilitation programs, we believe that it remains valuable for some patients.(237) The rehabilitation protocol used by this patient cohort was for full weight-bearing as tolerated

from postoperative day 1, with active strengthening and mobility progression as able. Patients with significant bone defects had modified weight-bearing restrictions in the first 6 weeks postoperatively. Modification were determined based on patient specific factors intraoperatively.
The patients in this cohort were familiar with knee specific rehabilitation, and providing the opportunity to choose between inpatient or outpatient rehabilitation likely gives the patient a sense of control and ownership of their recovery.

Other issues impacting the patient –

21 patients reported other health issues as current problems for them, but not difficulty with the RTKA. 13 patients had their concomitant problem as their primary response, 8 patients as a secondary response. There was significant variability in the issues described by the patients, which is reflective of the typical patient demographic undergoing primary or revision arthroplasty surgery. Patient concerns with other joints is common following knee arthroplasty,(238) with the majority of TKA patients having other musculoskeletal comorbidities.(239)
These responses support an important consideration in preoperative assessment and decision making for patients, in that the decision to proceed to a primary or revision knee replacement procedure should take into account comorbidities and the impact of these on the patient's overall condition and wellbeing. For example, if a patient has poor mobility due to multiple problems, then the expected improvement in mobility following TKA or RTKA may be minimal. Similarly, if the patient reports significant pain from multiple sources, TKA or RTKA may provide little benefit overall.
While it may be impossible to predict what health issues are pending for an individual patient, these comments do support the appropriate referral to colleagues and a multidisciplinary team approach in holistic patient management.
In this patient cohort, the duration from time of RTKA to review is up to 13 years, and therefore these issues may not have been present or symptomatic preoperatively.

"A stroke and vertigo are the only things that limit me"
"I have back troubles and other problems but the knee is good"
"Ankle difficulty with impingement. I am overweight and I think that's part of the problem"
"Other problems, but without them I would be fantastic"

“I’m slower now because I'm old”

Patient satisfaction –

Determining patient satisfaction can be a challenging task, particularly with a complex experience such as RTKA.(195) The factors which may contribute to overall patient satisfaction are unable to be fully identified or quantified, however we can and should investigate satisfaction as an important outcome measurement.(240)

Patient comments demonstrated a variety of responses related to satisfaction following RTKA. The experience of each patient is different, however many commented specifically or generally about their personal satisfaction. Using these comments, we are able to gauge an overall level of satisfaction from this patient cohort, and these comments can be a valuable addition to a numerical or quantitative assessment of satisfaction.

30 patients specifically expressed satisfaction in their comments. Some patient comments simply gave an indication of overall satisfaction, without specifically mentioning particular aspects of care contributing to their satisfaction. Therefore, the factors which contribute to satisfaction in these patients is not able to be determined. Other patients give some specific aspects of their outcome or experience which has contributed, at least in part, to their satisfaction. These comments suggest that the factors which contribute to satisfaction include the feeling of a “normal” or “natural” knee, which may be the absence of ongoing awareness of having a knee replacement in situ, or it may be the absence of pain and the ability to complete functional tasks without difficulty. The other factor expressed in satisfied patients includes the absence of complications or ongoing dysfunction.

Patients who are able to achieve a final outcome which meets their personal expectations regarding pain and function, and who do not encounter any serious complications in the future, will likely be satisfied with the RTKA procedure.(195)

This suggest that patients do not need to obtain a defined level of function or activity to be satisfied, but rather the completion of their personal activities of daily living, and met expectations regarding postoperative condition, may suffice for overall patient satisfaction.

“Very good revision, I am happy”

“My knee feels fantastic. I am very satisfied”

“Feels like a normal knee. I don’t have any problems at all. I’m happy”

“I tell everyone how good it is. Its great”

“I have no concerns or problems”

“I am pleased I've had it done”

“I don’t even notice I’ve had a knee replacement. It feels like a natural knee”

“It is fantastic, I am delighted, its blood perfect”

“The knee is great, it doesn’t stop me”

3 patients gave comments which suggest neither satisfaction nor dissatisfaction. These patients may trend towards satisfaction or dissatisfaction in the future, due to the influence of other factors and the progression of their personal experience with RTKA. For example, a subsequent infection and need for further revision surgery or hospitalisation may result in patient dissatisfaction with the RTKA process.

“I am the same”

“Things are not going too bad. No complications yet”

“I don’t have any regrets with having it done”

6 patients expressed dissatisfaction postoperatively. A combination of approaches toward dissatisfaction can be viewed from the comments given.
Some patients expressed dissatisfaction with their entire journey of knee arthroplasty procedures, and with retrospect, would avoid all knee replacement operations.

“Bad from the time of the first operation. I would avoid all the surgery again”

“I wish I had never had the first operation”

Another subgroup of patients expressed dissatisfaction following RTKA in comparison to following primary TKA. The possible outcomes after further surgery on any joint includes the potential for a poorer outcome. In these patients, further discussion and expectation management preoperatively may have changed the patient expectations postoperatively. These comments demonstrate the need to establish a shared understanding and well managed expectations before beginning the RTKA process.

“The revision is not as good as the first one was”

“Not as good as after primary”

“It could be a lot better. I’m not very happy. My expectations were not met after the revision”

The final patient who expressed dissatisfaction provides insight into the potential for ongoing issues and dysfunction following any surgery, but particularly relevant to revision joint replacement surgery.

“The revision was complicated by stem tip pain. Subsequent re-revision by Dr _____in Sydney after 10 years of pain. I had a hinge inserted, which has since been complicated by infection”

The development of sequential complications following further RTKA operations is an unfortunate reality for a small minority of patients.(241) The undertaking of any surgery, but specifically arthroplasty surgery, can result in a process of multiple operations and interventions to address complications from previous surgical intervention. The potential development of complications intraoperatively or postoperatively must be understood by the patient preoperatively, and every measure taken to avoid the development of such complications. However, despite the best efforts of the patient, surgeon, and wider surgical team, complications do still rarely occur. All patients must therefore be prepared to accept the risk of complications when consenting for even minor surgical procedures.

6.4 Conclusion:

Collecting patient comments and use of thematic analysis to evaluate an impromptu comment gives a glimpse into the holistic nature of the patient experience. Patient comments are likely focused on the factors of the greatest impact for the individual, and also likely represent the attitudes and focus of the patient in that moment. While this insight into the most significant issues for the patient at the time is valuable, it is not necessarily representative of their entire opinion and experience with RTKA. Although further questioning at a later time point may demonstrate a difference in patient experience and comments, this set of information gathered is still deemed valuable and important.

The majority of patients in this cohort underwent primary TKA to address pain and / or functional difficulties. They contemplate undergoing a RTKA procedure to provide a functional and painless knee when previous surgery has failed to do so. While the ability to complete activities of daily living alone is sufficient to meet some patients' expectations, other patients expect a greater level of functionality and return to more demanding tasks postoperatively.

The impact of RTKA surgery on a person is not easily quantified. As an individual, the patient is impacted in a myriad of ways, encompassing all aspects of a bio-psycho-social approach to health care. These factors, combined with the vast number of other influencing factors, contribute to form the patient's 'lived experience' of RTKA. These factors and others contribute in different ways and to different magnitudes for each individual patient, therefore it is impossible to identify and quantify each influence for an individual. However, the process of gathering a patient's comments allows us to gain some insight into the experience that an individual has had. This approach is a valuable addition to traditional assessment of outcomes in medicine, providing us with a basis for thought and discussion into the 'lived experience' for our patients now and into the future.

Despite all of the advances in operative skill and technology, the relationship that a patient has with their surgeon remains of primary importance in their overall experience of RTKA. It is reassuring that this remains central to medical practice in the current era of healthcare provision.

CHAPTER 7: A RELIABLE SURGICAL APPROACH TO REVISION TOTAL KNEE ARTHROPLASTY

Abstract

Introduction / Background:

The surgical exposure obtained in Revision Total Knee Arthroplasty (RTKA) should facilitate the utilisation of instrumentation and implants, including adjuncts such as stemmed prostheses, bone allograft and artificial augments.

We have previously identified within this cohort of RTKA patients a high satisfaction rate of 93.5% at mean 6.5 years of follow up and a high level of postoperative function. We therefore seek to describe in detail the operative technique, perioperative care, and report the complications and their management.

Methods:

We report on the surgical approach, closure technique and postoperative care used by the senior author for RTKA procedures. The patient demographics, intraoperative details and postoperative outcomes are also reported.

We aim to provide a clear description of intraoperative technique and postoperative outcome, facilitating adoption or comparison with other surgeons / techniques.

Patient inclusion criteria were: RTKA by the senior author (RR), PFC (Depuy) prosthesis, at John Flynn Private Hospital, with a minimum of 2 years since RTKA. A retrospective chart review was combined with a structured telephone assessment questionnaire to assess outcomes.

Results:

202 RTKAs were available for follow up in 185 patients. The mean 1 year postoperative ROM was 110 degrees.

Key features of surgical approach include incision planning, soft tissue plane development, parapatella scar debridement, safe removal of implants, management of bone defects, and closure technique.

The overall 90 day complication rate was 9%, including 4.4% requiring MUA, 3% superficial surgical site infection (1 patient requiring IV antibitotics).

Conclusion:

We suggest that this technique is reproducible, reliable, rarely requires modification, and facilitates successful postoperative outcomes with low complication rate.
The adoption of this surgical technique allows surgeons to approach complex knee arthroplasty with confidence in the appropriate exposure of anatomy, facilitating subsequent steps in their arthroplasty procedure.

7.1 Introduction:

Revision total knee arthroplasty (RTKA) is widely accepted as a challenging operative procedure.(9, 10, 242) The reasons for increased difficulty of surgery and poorer postoperative outcome has been attributed to difficult surgical exposure, stiffness, adhesion of tissues, instability due to ligamentous laxity and poor bone stock.(10, 242) The surgical exposure required in RTKA should facilitate the utilisation of instrumentation and implants, including adjuncts such as stemmed prostheses, bone allograft and artificial augments. Appropriate surgical exposure in RTKA is integral to obtaining a satisfactory outcome.(243)

We have previously identified within this cohort of RTKA patients a high satisfaction rate of 93.5% at mean 6.5 years of follow up and a high level of postoperative function. We therefore seek to describe in detail the operative technique, perioperative care, and report the complications and their management.

Research question:
In this RTKA cohort, what is the complication rate and postoperative outcomes for patients receiving this surgical approach / technique?

Hypothesis:
We hypothesise that patients in this cohort will demonstrate a low complication rate and high quality postoperative outcomes.

7.2 Methods:

We report on the surgical approach and closure operative technique used by the senior author for RTKA procedures. The patient demographics, intraoperative details and postoperative outcomes are also reported. We suggest that this technique is reproducible, reliable, rarely requires modification, and facilitates successful postoperative outcomes with low complication rate.
We aim to provide a clear description of intraoperative technique and postoperative outcome, facilitating adoption or comparison with other surgeons / techniques.

Description of technique –

The patient is positioned supine, after spinal or general anaesthesia. Tranexamic acid is administered preoperatively (1 gram orally, 2 hours prior to surgery) unless contraindicated. The limb is positioned with thigh and foot bolsters. No tourniquet is applied, to minimise adverse effects of tourniquet use including thigh pain(244), postoperative quadriceps inhibition(244, 245), DVT(246), or patella tracking / soft tissue balancing difficulties.(247, 248) We consider tourniquet use to have no advantage in overall blood loss.(246, 249)

Surgical approach –

The previous incision is used whenever possible. If use of the previous incision is not appropriate, an adequate skin bridge between the new and the previous incision is maintained. Meticulous soft tissue handling and avoidance of undermining skin and subcutaneous layers is ensured. Haemostasis with diathermy is performed.

A paramedian longitudinal incision through retinaculum and capsule is performed. No quadriceps snip is routinely performed. The incision is typically 20-25 cms in length, depending on patient body habitus and localised adiposity. It extends distally to approximately 3 cms below the tibial implant-bone interface. Adequate exposure is considered of greater importance than a short incision.

Image 1 – Skin incision and superficial dissection

To obtain adequate exposure and mobility of the extensor mechanism, the medial gutter must be cleared of adhesions. Scar tissue can be divided using finger dissection or curved heavy scissors. Care must be taken to ensure appropriate plane of dissection. This dissection should be carried beyond the femoral epicondyle. The lateral gutter should be released in a similar fashion to ensure scar tissue does not impact soft tissue balance or range of motion intraoperatively or postoperatively.

Image 2 – Scar adhesions within medial gutter

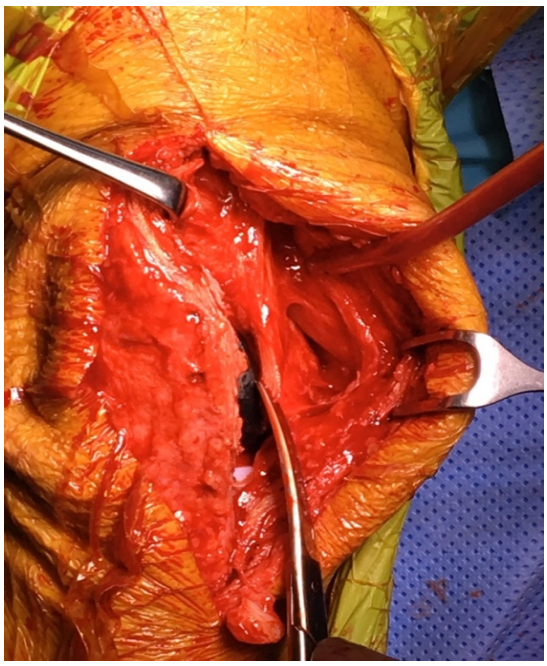

Image 3 – Removal of adhesions in medial gutter with heavy curved scissors

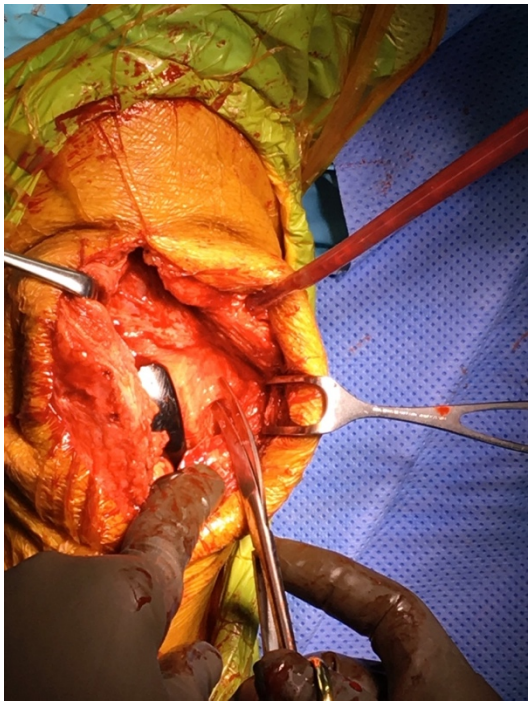

Image 4 – Removal of adhesions with heavy curved scissors

Parapatella scar is then identified and debrided. Excision should be performed, whilst preserving a layer of fat on the tendon surface. The lateral side of the patella should be cleared of scar tissue for a distance of approximately 10mm.

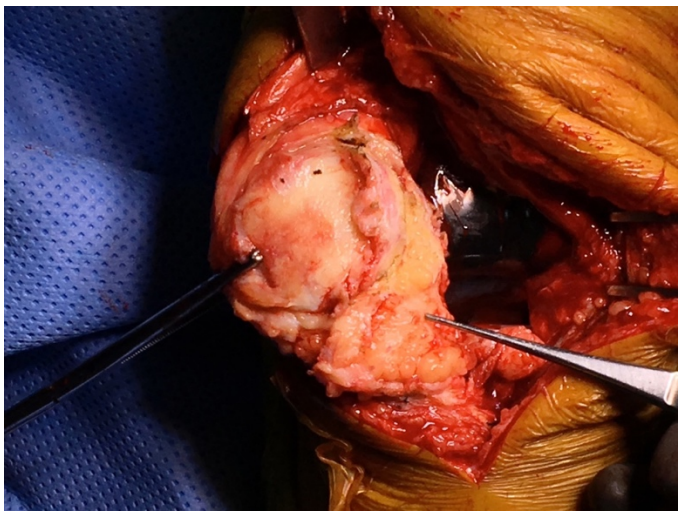

Image 5 – debridement of parapatella scar

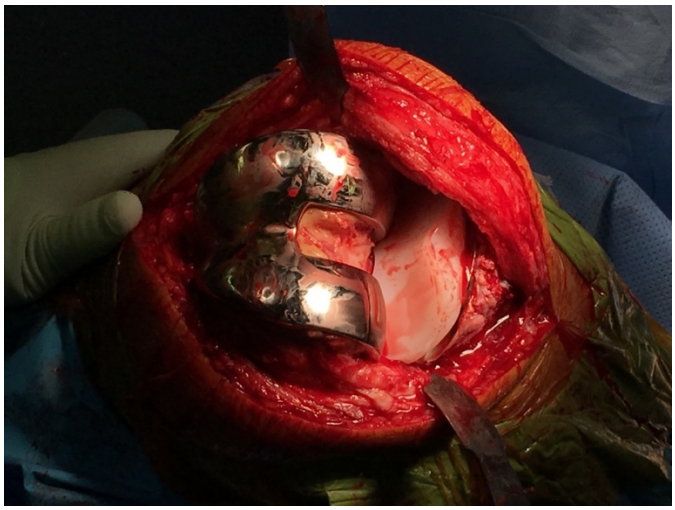

Image 6 – Adequate exposure achieved to allow removal of implants

This exposure and debridement of scar tissue should then allow for the removal of the tibial polyethylene liner. This is performed utilising prosthesis specific instrumentation or an appropriate surgical instrument.

Removal of implants is then performed, with attention focused on safe removal of implants and avoidance of periprosthetic fracture. A small interface is developed at the implant-cement or implant-bone junction. This is usually begun with a small offset osteotome, and then developed with a microsagittal saw. A reciprocating saw for this purpose should be used with great care and only in experienced hands. When complete, the implants can then be tapped loose using specific prosthesis removal devices or a small punch and mallet.

The femoral component is usually removed first, allowing greater access for removal of the tibial prosthesis. Care should be taken to ensure that the direction of force when tapping out the implant is parallel to any intramedullary stem and other longitudinal implant surfaces to minimise risk of fracture.
Removal of the tibial tray is facilitated by anterior subluxation of the tibia and deep flexion of the knee. This enables the tibial tray and stem to pass distal to the distal femoral surface. The use of retractors to lever the proximal tibia should be performed with caution given the often poor bone stock and risk of fracture.

Further removal of cement and debridement of bone and soft tissue surfaces can then be performed with increased exposure and access to all aspects of the knee joint. In most revisions and all re-revision cases, multiple specimens are taken for frozen section analysis and assessment of White Cell Count per high-powered field. Leukocyte-esterase testing of synovial fluid is also performed intraoperatively.

The implant used in all RTKA cases was the PFC prosthesis (Depuy Synthes, Warsaw, IN). This implant was used based on the preference and standard practice of the surgeon. A combination of adjuncts were used intraoperatively based on need at the time of surgery, such as stemmed implants, sleeves, bone augments and artificial augments. Details are included in table 2.

Closure –

Following definitive implant insertion and final check of stability, soft tissue balance, patella tracking and range of motion, an iodine lavage of the joint for 5 minutes is performed. Further wash and check of haemostasis is then performed. A drain is placed prior to closure of deep layers, exiting from the superolateral aspect of the suprapatellar pouch. Retinaculum is then closed with a size 2 PDS (monofilament, synthetic, absorbable) suture using a combination of interrupted and running suture technique. This is followed by closure of fat and fascia with 2-0 vicryl (braided, synthetic, absorbable). Iodine lavage of fat, fascia and skin is performed. Subcuticular closure with 3-0 monocryl (monofilament, synthetic, absorbable) suture is followed by a topical skin adhesive and surgical dressing. A compression bandage is applied over the sterile dressings.

1 gram oral tranexamic acid is administered at 2 hours and 6 hours postoperatively. The surgical drain and compression bandage are removed 8 hours postoperatively. Apixaban oral anticoagulation is commenced 8 hours postoperatively. Suitability of chemical VTE prevention is considered based on patient specific risks and comorbidities.

Postoperative rehabilitation –

Patients are encouraged to mobilise with physiotherapy assistance on the day of surgery. Most patients will be allowed to full weight bear as tolerated, with exception of patients with significant structural bone graft used intraoperatively. These patients would be protected weight bearing with crutches until adequate structural stability is obtained.

The operative limb is elevated whilst in bed, with bed tilt or limb elevation pillow. Patients are encouraged to sit out of bed as soon as comfortable, with the operative leg placed on a skateboard to encourage gentle ROM. Passive extension exercises are performed for 10 minutes, three times per day.
Patients are progressed onto an exercise bike on day 2 postoperatively. The knee flexion required for exercise bike riding is approximately 100-105 degrees, with alterations depending on seat height and leg length.(250) Patients are required to mobilise on stairs prior to discharge. Patients are discharged once safe, mobile and comfortable.

7.3 Results:

202 consecutive major RKTA procedures were performed in 185 patients between 2004 and 2015 inclusive. Orthopaedic and medical records were retrospectively reviewed. Demographic data are detailed in Table 1. This cohort demonstrated heterogeneity in gender, age, weight, BMI, ASA score, diabetes status and reason for RTKA.

Intraoperative details are described in Table 2. Of this patient cohort, only 5 RTKAs required tibial tubercle osteotomy to allow adequate surgical exposure. The used of a tibial tubercle osteotomy was rarely required, and used when inadequate surgical exposure was obtained following the techniques described above. All patients received a PFC (Depuy Synthes, Warsaw, IN) prosthesis. A variety of implant levels of constraint were used, and

use of stemmed implants, bone allograft or artificial augments was common. Antibiotic cement was used in all cases. Mean surgical time was 143 minutes.

Postoperative outcomes are described in Table 3. A clinically significant improvement in mean ROM was recorded from preoperatively to 1 year postoperatively. Complications within 90 days of operation were found in 19 cases. 6 late complications of infection requiring subsequent revision were identified. There was no evidence of this complication within 90 days of RTKA. 3 of these cases were following 2-stage revision for infection.

Number of patients	185
Gender	97 Male, 88 Female
Age at time of RTKA (years)	Mean 70.5 (range 45 to 90)
Patients with prior RTKA	37
Weight (kgs)	Mean 83.4 (range 49 to 130)
BMI	Mean 29.5 (range 19 to 46)
ASA	Mean 2.5 (range 1-4)
Diabetes	26 diabetics (2 type 1, 24 type 2, 22 patients unknown)
Smoking status	8 current smokers, 56 past smokers, 19 smoking status unknown
Reason for Revision	Loosening 36% (71) Infection 23% (47) UKA failure 9% (17) Instability 7% (15) Pain 6% (12) Polyethylene wear 5% (11) Stiffness 3% (7) Implant failure 3% (7) Periprosthetic fracture 3% (7) Component malposition 2% (5) PFJ pain 1% (2) AVN tibia 1% (1)
Mean Pre-operative ROM	98 degrees (range 15 to 140 degrees)

Table 13 – Patient demographics (2)

Medial Parapatella approach used	202
Tibial Tubercle Osteotomy required	5
Implant constraint	57 CR, 101 PS, 32 TC3, 12 Hinge
Stemmed implants	170 (134 Femur and tibia, 7 Femur alone, 29 tibia alone)
Bone augments	82
Artificial augments	117
Cemented implants	202
Antibiotic cement	202
Mean Surgical time	143 minutes

Table 14 - Intra-operative details

Mean 3 Month post-operative ROM	103.3 degrees
Mean 1 year post-operative ROM	110.9 degrees
Complications within 90 days of RTKA	19 total (9%)– 9 MUA required (4.4%) 6 Surgical Site Infection – 1 requiring IV antibiotics, 5 requiring oral antibiotics (3%) 1 wound dehiscence post fall (0.5%) 1 haemarthrosis (0.5%) 1 post-operative pain requiring readmission (0.5%) 1 Pulmonary embolism (0.5%)

Table 15 - Post-operative outcomes

7.4 Discussion:

We believe that there are a number of factors which have contributed to the high quality outcomes and low postoperative complication rate for patients within our cohort. Firstly, all operations were performed by an experienced arthroplasty surgeon, familiar with the prosthesis and intraoperative insertion technique. While the operative approach and exposure is an important part of overall RTKA procedure, other aspects of RTKA must also be performed adequately to obtain a successful outcome.
Secondly, the prosthesis used has demonstrated high quality long term outcomes, with low revision rate over 15 years.(6)
Thirdly, these patients underwent a well-structured postoperative physiotherapy and rehabilitation program within a private healthcare setting.

9 patients required manipulation under anaesthesia to enable good postoperative ROM. Pre-operative mean total ROM was 67 degrees, markedly lower than the mean of 98 degrees. At 1 year postoperatively, the mean total ROM for these patients was 98 degrees. Although the 1-year ROM was only 98 degrees, this was a clinically significant improvement for these patients.

1 patient developed a haemarthrosis secondary to warfarin anticoagulation, necessary due to medical comorbidities. This was managed conservatively, and obtained a total ROM of 135 degrees at 1 year postoperatively.
1 patient developed a pulmonary embolism despite receiving standard anticoagulation postoperatively. This was managed with appropriate anticoagulation following involvement of specialist physicians.

6 patients developed a superficial surgical site infection, managed with a short course of oral antibiotics in 5 cases, and intravenous antibiotics in 1 case. This postoperative complication did not affect postoperative satisfaction or outcomes. 4 of 6 patients were available for satisfaction outcomes, all of whom were satisfied with their RTKA. The mean ROM for this group was 115 degrees (range 95 to 135), and mean OKS was 44 (range 37 to 48).

6 (3%) patients developed a deep infection after at least 6 months post RTKA (mean of 3.6 years) and required further operative intervention. 1 patient required a return to theatre for repeat closure of the superficial wound after falling from bed whilst on the ward. No breach of the deep closure was evident intraoperatively.

This surgical approach required modification in only 5 of 202 RTKAs. Della Valle et al reported a similar series of RTKA procedures using a medial capsular approach. 15 of 126 patients required modification of surgical approach to obtain adequate exposure.(243)

Tibial Tubercle Osteotomy has been well described in the literature, with variable outcomes and complication rates between authors. It is widely accepted as an option to allow for adequate exposure during knee arthroplasty procedures, with the goal of avoiding detachment of the patella ligament from the tibial tubercle.(251-253)
Complications are reported by most authors with published series of TTO during arthroplasty, including fracture, fragment displacement, malunion, skin necrosis, difficulty kneeling and lower patient satisfaction.(242, 252, 254, 255)
Reported complication rates of approximately 5% to 10% by most authors dictate its use only when required, and requires considerable surgical expertise to obtain good outcomes.(253, 255-257) We suggest that avoidance of TTO when possible through alternate surgical exposure techniques is desirable.

Comparison of the described technique and postoperative outcomes with other techniques or patient cohorts is not possible at this time, due to the absence of such outcomes within the literature. We would encourage the orthopaedic community to pursue a critical comparison with other RTKA cohorts, in efforts to further develop understanding of surgical approach and optimising patient outcomes.

7.5 Conclusion:

This surgical technique for RTKA has been reproduced in over 200 patients, with very few requiring modifications intraoperatively. This surgical exposure has facilitated subsequent aspects of RTKA surgery, which has facilitated low complication rates postoperatively. The adoption of this surgical technique allows surgeons to approach complex knee arthroplasty with confidence in the appropriate exposure of anatomy, facilitating subsequent steps in their arthroplasty procedure.

CHAPTER 8: DISCUSSION

8.1 Summary of findings and Clinical relevance –

This cohort of RTKA patients demonstrated a survival rate of 93.5% with a mean follow up of 6.5 years. Postoperative outcomes demonstrated a ROM at 1 year of 112 degrees, a clinically and statistically significant improvement from preoperative ROM of 100 degrees. Mean reported OKS was 39.25.
Postoperative ROM was associated with preoperative ROM, reason for RTKA, and number of previous RTKA operations.
Higher OKS was found in males, those with fewer previous RTKA operations, those with increased pre-operative ROM, and use of a less constrained implant.
Less constrained implant use was associated with a lower likelihood of failure.

85% of patients were satisfied with their RTKA outcome. Mean patient reported score (1-10) of 8.17, and mean MSS score of 87.7 was demonstrated in this cohort.
Satisfied patients had increased OKS and ROM. Statistically significant predictors of patient satisfaction identified included OKS, BMI and surgical time.

Qualitative investigation of a patient's experience of RTKA demonstrated common themes of importance, including the surgeon(s) involved in care, preoperative condition and change in condition following RTKA, postoperative level of function and ability to complete specific activities, impact of RTKA on pain perioperatively and postoperatively, rehabilitation and recovery, and other issues affecting patient quality of life.

Detailed description of surgical technique, perioperative care, and postoperative outcomes is reported to provide an opportunity for adoption or comparison of techniques by other surgeons. We report a low complication rate (9%) and successful outcomes within this cohort, with a reproducible and effective surgical approach to RTKA.

8.2 Comparison to similar studies -

6 published studies with aims similar to our research were identified during the literature review process (see Table 1). Review of these previous studies and the identified outcomes supports the need for further investigation into RTKA. The previously published research has demonstrated a number of limitations, which we have sought to improve upon with this research. Some of these limitations are unfortunately unavoidable given the nature of RTKA, such as small patient cohorts and the inability to control or standardise many variables intra- and peri-operatively.

Of the 6 similar studies identified, the mean follow-up ranged between 24 months to 8.1 years. Only 3 studies had a mean follow up of 5 years or longer.
2 studies included a cohort of over 150 patients, the largest cohort including 499 patients. Of this cohort, there was no standardization of surgeon or prosthesis, among other potential confounding factors.
2 studies reported outcomes from a single surgeon, removing the significant variable of operating surgeon from outcomes. 3 studies did not specify the number of surgeons involved.
3 studies assessed outcomes from a single prosthesis. The impact of prosthesis on RTKA outcomes remains incompletely understood, however the ability to control this potential confounder provides researchers and clinicians with greater confidence in the reported outcomes.
Outcomes were determined by chart review, clinical assessment, or a combination of these methods. The results and conclusions of previous authors varied between studies, and limited consensus is available at this stage.
In all aspects of this research, we have accurately reported our methods to enable reproduction of this research within other cohorts.
In comparison to the previous studies reporting postoperative outcomes following RTKA, our research provides the second largest cohort of patients from a single surgeon utilizing a single prosthesis. The methodology employed in our research is consistent with previous studies, and our results are therefore able to provide a robust point of comparison with other authors.

Patient satisfaction outcomes have been assessed and reported in arguably the most

robust way to date within the RTKA population. Analysis of outcomes has enabled the identification of contributing variables which can be further assessed in future research.

The qualitative assessment of patient experience of RTKA is the first within the published literature. This provides an alternate perspective of patient outcomes following RTKA, a trend which continues to gain acceptance and popularity in orthopaedics and other fields.

Accurate description of surgical technique, combined with postoperative outcomes, provides a robust benchmark for surgeons to compare other cohorts. Description of this kind was not able to be identified in previously published literature.

8.3 General Discussion

RTKA is widely regarded as a difficult orthopaedic operation, due to the nature and variability of preoperative, intraoperative and postoperative challenges. This is well represented by the large number of reported causes of failure in published literature. Therefore, RTKA should not be undertaken without significant consideration and discussion by both surgeon and patient.

In patients who have demonstrated significant deterioration of existing arthroplasty due to infection, the decision to proceed to RTKA is simpler and clearer for patients and surgeons alike. Appropriate, timely management of the infected arthroplasty is of vital importance to manage the morbidity and mortality associated with such a clinical situation.

However, in patients who are dissatisfied postoperatively, but without evidence of infection or acute systemic deterioration, the decision to undertake RTKA requires greater consideration of options, outcomes, and expectations.
This distinction provides an understanding of different treatment principles, and may be used to guide patient understanding of the considerations of further management.

Patients who have experienced a poor outcome postoperatively should undergo appropriate investigation to determine a surgically correctable cause of their dissatisfaction. The understanding of influencing factors following knee arthroplasty remains poorly understood, and likely involves a combination of surgical and nonsurgical

factors. It is important that surgeons understand which of these factors are able to be addressed through further surgical intervention, and those that are not. Without a surgically correctable cause of failure, RTKA in this patient group should not be undertaken. Doing so would expose the patient to significant risk during perioperative period as well as postoperative recovery, with no reasonable expectations of improvement in clinical outcome.

If a surgically correctable cause is identified, then extensive discussions with the patient regarding pathology, surgical and nonsurgical options, and the perioperative and postoperative care should be undertaken. Patients should be informed of the current paucity of evidence supporting successful long-term outcomes following RTKA, and the increased rates of complications and further revision postoperatively.

In patients who have sustained a serious postoperative complication requiring prompt surgical intervention, such as periprosthetic infection or periprosthetic fracture, the above discussions with the patient are necessary, but few alternatives to revision surgery are appropriate if the patient is to resume adequate function or have minimal pain.
Following this process, the surgeon must determine if he or she is able to undertake such a procedure individually, or if involvement of experienced colleagues is necessary. Consideration of referral of the patient to an experienced RTKA surgeon should occur. Surgeons with a low volume of RTKA procedures or who have limited experience in RTKA should consider involvement of senior experienced surgeons in the provision of surgical care.

The approach that Dr Randle utilizes for RTKA can be summarized to provide a framework on which to build a logical, structured approach to RTKA surgery.

Firstly, pre-operative diagnosis and intraoperative assessment for infection is critical, with conversion to 2-stage revision procedure if evidence or clinical suspicion of infection exists. Proceeding to definitive prosthesis implantation without excluding infection will likely result in further failure and subsequent operative intervention being required.

Secondly, pre-operative planning should consider the use of available implant combinations, stemmed implants for increased stability, structural bone and artificial

augments to address defects, and any other equipment or prostheses which may be required intraoperatively. While the use of navigation is not adopted by Dr Randle, this may be deemed of value for other surgeons undertaking RTKA. The importance of pre-operative planning and availability intraoperatively of adjuncts cannot be overlooked, as this facilitates a surgeon's ability to achieve the desired outcome intraoperatively. Given the complexity of RTKA surgery, it is vital that unintended modification of the surgical plan due to lack of resources is avoided whenever possible.

Thirdly, the implant fixation and joint should both anticipate long term stability at the completion of the case. It is appropriate to accept increased level of constraint rather than instability. The use of hinged or constrained implants enables acceptable function and satisfaction postoperatively, and therefore their use should not be avoided when the clinical situation requires.

Fourthly, postoperative rehabilitation should be performed as per primary TKA, with consideration of weight bearing status variability based on bone graft use. A structured approach incorporating appropriate analgesia, oedema management and obtaining range of motion and stability to allow for protected mobilisation likely facilitates early safe discharge and good postoperative outcomes.

Common difficulties encountered intraoperatively during RTKA are often attributable to prior surgical intervention. RTKA involves the management of complications, and therefore adds an additional level of complexity and uncertainty to standard arthroplasty procedures. The challenges encountered intraoperatively during RTKA are diverse, including distorted anatomy and lack of anatomical landmarks to guide implant positioning, difficult surgical approach and dissection due to post-surgical scarring, deficiency of bone stock to allow implant stability, and the potential for infection perioperatively or postoperatively. These challenges may necessitate the use of complex implants and surgical techniques, extended operative time, and high level surgical experience and expertise to obtain successful outcomes.

Distorted anatomy / anatomical landmarks – Appropriate positioning of implants can be difficult in the revision setting, due to the prior removal of articular surfaces and therefore

inability to reference from these anatomical landmarks. Often, only the femoral epicondyles are still available for referencing implant position. The level of the joint line may be determined based on fibula head position, meniscal remnants or femoral epicondyles.
Distorted bony or soft tissue anatomy must be identified preoperatively, as modifications may be required to ensure appropriate restoration of bony structures and constraint from soft tissues. Where prior soft tissue releases have been performed, increased constraint implants should be considered. When bone stock is suboptimal for stable implantation of implants, utilization of structural bone, artificial augments, or other reconstruction techniques are indicated.

Surgical approach – As described in the preceding surgical approach chapter, a standardized surgical approach is used by Dr Randle in the vast majority of RTKA operations. This allows for a reproducible exposure of anatomical landmarks and relevant structures. Modification of this approach is considered when the surgical approach for previous surgeries has been a lateral parapatella approach, or when another surgical incision results in a narrow soft tissue interval between incisions. Such a situation can result in compromise of wound healing and potential for soft tissue breakdown of the resultant skin bridge. When required, extension of the standardized approach can be utilized, through a tibial tubercle osteotomy or proximal extension. Respect of the soft tissues and avoidance of devascularisation allows for confidence in soft tissue integrity postoperatively. Rarely is significant difficulty encountered in the closure of wounds when using this approach.

Infection - Dr Randle’s approach to eradication of periprosthetic infection following TKA requires the removal of all implants and appropriate debridement of bone and soft tissues, followed by implantation of a cement spacer. Antibiotics are administered based on empirical treatment guidelines and refined through intraoperative culture sensitivities. Involvement of the Infectious diseases team is beneficial in ensuring adequate dosage and duration of antibiotics.
The single stage revision for infection has not been adopted by Dr Randle. Despite the risks involved in a 2-stage surgical procedure, this method of eradication has been successful in Dr Randle’s patient cohort, and therefore is the standard practice.

Other methods utilized by Dr Randle to minimize infection risk during RTKA include intravenous antibiotics at induction and re-dosing at 2 hour intervals, apart from cases for infection when samples are taken prior to IV antibiotic administration.

A combination of assessment tools to identify infection are employed during a second stage RTKA for infection. Following surgical skin preparation and draping, the knee is aspirated and intraarticular fluid is assessed using leukocyte esterase testing in theatre.(258)
8 or more samples are then taken after surgical exposure, and frozen section testing is performed to ensure absence of organisms on high powered microscopy. The samples are taken from intramedullary canal of femur and tibia, prosthesis-bone interface of the femur and tibia, synovium and joint capsule, and any other tissue concerning for infection on inspection.

Dr Randle also ensures adequate debridement of bone and soft tissues, and performs an iodine based solution soak of the implant for 5 minutes intraoperatively, following implantation of the definitive prosthesis.(259) Ensuring haemostasis and appropriate soft tissue handling and closure of surgical incision is performed. Postoperatively, 3 further doses of intravenous antibiotics are administered in the 24 hours postoperatively.
Following a first stage revision for infection, intravenous antibiotics are administered for at least 6 weeks, in conjunction with an infectious diseases specialist.

In a limited number of resistant infections in immune suppressed patients, a portacath has been inserted into the joint. This allows for very high antibiotic concentration within the knee joint whilst maintaining safe serum levels. This technique is performed in consultation with Infectious Diseases specialists and has been successful in the small cohort of its use.

Postoperative outcomes -

Patient outcomes following RTKA are not well understood, and therefore difficulty remains for clinicians to counsel patients preoperatively, to manage expectations regarding function postoperatively, and to assess and critique their outcomes compared to their peers.

RTKA is a complex procedure, with each case presenting individual difficulties and challenges, and therefore it remains unreasonable to predict functional outcomes postoperatively. However, with increasing understanding of reproducible techniques and approaches to specific subgroups of RTKA patients, an overall estimate of function may be able to be developed.
The main difficulty in this endeavor is gathering and interpretation of clinical data. There are a number of factors which impact this, including the low number of RTKA procedures performed, the significant variability in pathology or cause of failure, differences in approaches to RTKA surgery and surgical goals, as well as different methods for collecting, assessing and reporting outcomes. Further compounding these challenges is the reporting of patient outcomes from individual authors, most of whom are high volume RTKA surgeons relative to their peers. Those surgeons who have extensive experience and high volume of RTKA cases will likely have better outcomes than less experienced or lower volume RTKA surgeons. This artificially improves the reported outcomes following RTKA surgery.

Our cohort does little to address these issues, however we do report a large series of RTKAs with successful outcomes. Patients achieved a mean ROM of 112 degrees at 1 year postoperatively, increased from 100 degrees preoperatively. Patients report a mean OKS of 39.25, and a survival rate of 93.5% at mean follow up of 6.5 years. This should provide encouragement to patients and clinicians alike, that successful outcomes are achievable following RTKA. In its current form, our results have limited external validity.

Preoperative and patient factors demonstrated statistically significant impact on outcome variables, and can therefore be used to guide patient expectations. We demonstrated statistically significant influence of pre-operative ROM and intraoperative techniques on post-operative OKS and ROM at 3 months and 1 year. For example, Patients who required a hinged prosthesis had lower OKS postoperatively. These findings enable surgeons to appropriately plan for likely intraoperative requirements, and to establish a shared understanding with the patient and surgical team regarding intraoperative and postoperative challenges.

Failure of RTKA within this cohort was further investigated. Of the cohort of 153 patients available for telephone follow up, 10 RTKAs had experienced failure and undergone

further RTKA surgery. In the remainder of the total cohort of 202 RTKAs, charts were reviewed for any suggestion of failure or re-revision surgery. None of these patients were identified to have experienced failure of RTKA.

The 10 RTKAs that experienced failure occurred in 9 patients, 1 undergoing 2 failures, both for infection. 5 patients were male and 4 were female. The mean age at RTKA surgery was 67 years. The mean duration of RTKA prior to failure was 4.4 years, range 0.6 to 10 years. The cause of failure of primary TKA in these patients was infection in 5 cases, loosening in 3 cases, stiffness in 1 case and periprosthetic fracture in 1 case. 4 patients had previous RTKA surgery on the joint in question prior to undergoing RTKA in this cohort. The patients in this group had a mean BMI of 27, 1 patient was a type 2 diabetic on oral agents, 1 patient was a past smoker. All patients were ASA 2 or 3.

The predominant reason for failure of RTKA was infection. This occurred in 2 of 2 failures within 1 year, 4 of 6 failures within 5 years, and 6 of 10 failures in total. The other causes for failure were periprosthetic fracture, impingement, loosening, and pain.

This cohort had 101 patients who reached 5 years of follow up, resulting in a 5 year survival rate of 94% (95/101). The survival rate at 10 years was 60% (15/25), which was markedly lower likely due to a smaller number of patients reaching 10 years of follow up. This reported survival rate includes failure of all types, including infection. A total of 42 patients have greater than 10 years since RTKA, including those who were unable to be contacted by telephone. Although their revision status cannot be definitively confirmed, this would result in a survival rate of 76% (32/42).

This reporting of patient outcomes following RTKA by a single surgeon, using a single prosthesis remains one of the largest and most comprehensive in the published literature. We believe that these results are of a high quality and the patient outcomes are successful.

Patient satisfaction -

Patient satisfaction is arguably the most important outcome postoperatively, yet until recently it has been an area of limited investigation and focus. Patients who have their

expectations met, based on appropriate discussions, will be patients best served by the healthcare system.

There remains a paucity of literature regarding patient satisfaction following RTKA, with no consensus regarding measurement of patient satisfaction or what outcomes can be regarded as a positive outcome postoperatively. Few authors have assessed satisfaction as an outcome measure following RTKA, and those who have described satisfaction rates have not adopted a widely accepted method of assessment, or described their method for assessment in sufficient detail to enable reproduction by other surgeons.

To address the primary objectives of this research, we sought to identify and utilize simple and reproducible methods of satisfaction assessment in our cohort. Our review of the literature revealed no gold standard for satisfaction, but rather significant variability in methods. Therefore, we chose to utilize a validated assessment method for primary knee arthroplasty, the Mahomed Satisfaction Score(133), as well as asking the patient “would you have the revision total knee replacement again?”, and obtaining a verbal score from 1 (very dissatisfied) to 10 (very satisfied). This patient cohort demonstrated a high level of satisfaction, with 85% of patients stating that they would have the RTKA again, and an average numerical score of 8.17. These satisfaction measurements are similar to that following primary TKA, and therefore we consider this to be a successful outcome in this population. Given the aforementioned paucity of published studies on satisfaction following RTKA, we cannot directly compare our results with other authors. Instead, we present a satisfaction rate which we believe establishes a benchmark for patient outcomes following RTKA.

Patient satisfaction is likely influenced by a number of factors, many outside of the surgeon’s control. In primary TKA, factors of great significance include patient expectations being met, as well as pain relief, satisfaction with hospital stay, and OKS.(260) It is therefore necessary for surgeons to appropriately counsel patients regarding their potential and likely outcomes following RTKA surgery. With appropriate preoperative communication and the development of a shared understanding, we believe that patient expectations can be managed to ensure that realistic expectations are held and maintained peri-operatively and postoperatively. While we do not suggest actively seeking to lower patient expectations pre-operatively to allow for greater satisfaction, we would caution surgeons in predicting excellent outcomes for all patients.

Patients within this cohort underwent extensive pre-operative investigation and counselling regarding their cause of failure and likely outcomes postoperatively. Patients then underwent RTKA by an experienced surgeon, in a private healthcare facility, with multidisciplinary perioperative care, a structured rehabilitation program, and extended inpatient rehabilitation when deemed of clinical benefit. Therefore, we would suggest that these factors may contribute to greater patient satisfaction, irrespective of intraoperative factors. This opinion is however not supported by any scientific evidence.

The "Lived Experience of RTKA" -

The methodology employed to assess patient perspective and lived experience of RTKA is consistent with other authors and publications. We believe that this method provides the ability to identify and consider other factors which contribute to the patient experience and satisfaction following not only RTKA, but all surgical intervention. While thematic analysis of patient comments may be considered by some authors as lacking in scientific rigor, we believe that the importance of patient experience should not be overlooked.

The completion of this assessment within a single surgeon series was used based on the concurrent assessment of this patient cohort. The replication of this research, using multiple surgeons' patient outcomes or specific patient subgroups is a valuable consideration for future research, but is beyond this research. The reported outcomes within this research will likely guide further research in this area in the future.

Our cohort of 102 patients who provided comments was significantly lower than those able to complete other aspects of patient telephone assessment. All patients were asked for comments and no patients were excluded from providing comments. We do not believe that this low response rate demonstrates dissatisfied patients, but rather is more likely to represent patients for whom their RTKA procedure has become a part of their normal life. We postulate that if given a longer period to reflect on their personal experiences, the response rate would be much higher than captured with our methodology.

Surgical approach and perioperative care -

The surgical approach utilized to obtain appropriate dissection, identification and protection of structures during RTKA surgery is varied between surgeons and between patients. The nature of RTKA results in each case displaying individual challenges and intraoperative obstacles to be overcome.
The technique described has been used in over 200 RTKA operations by an experienced arthroplasty surgeon. During this time, the technique has been refined and tested, with successful postoperative outcomes. Very rarely were significant changes to the standard approach required intraoperatively. Therefore, based on clinical experience and results, we describe a reliable and reproducible technique for surgical exposure in RTKA.

The operative experience and abilities of a surgeon vary between individuals, and develop over time with increasing understanding and insight into complex surgical procedures. It is important for the RTKA surgeon to have an adequate skill set and experience to address intraoperative issues which may arise unexpectedly. It is not possible for a surgeon to develop surgical ability from knowledge alone, it must be combined with appropriate practical implementation of this knowledge, to obtain sufficient experience to overcome the learning curve associated with a new technique, and therefore obtain competence in it.

While we believe and have demonstrated that the described technique yields successful patient outcomes, we do not believe that this technique can be relied upon for all patients. A small minority of patients may require a different approach, or modifications of this technique to obtain a successful outcome. Therefore, we encourage the consideration of its use in the learning and development of orthopaedic surgical techniques, with concomitant experience and abilities to modify the surgical approach when necessary. We acknowledge that other surgeons may have different surgical approaches for RTKA and obtain successful patient outcomes. We would encourage the description and sharing of these operative techniques to enable a greater understanding of varied methods to obtain a successful outcome, thereby enabling surgeons to be better equipped intraoperatively.

The surgical approach in RTKA facilitates the subsequent stages of the operation, however in itself it is likely only a small contributor to overall outcome. We do not suggest that the use of this approach directly results in better patient outcomes postoperatively, but

we do suggest that the proficient use of this approach enables subsequent stages of the RTKA to be performed effectively.

Strengths and limitations –

The methodology of this research was developed to enable a reproducible framework for assessment of patient outcomes following RTKA. While we acknowledge that the study design does have limitations, we believe that it is suitable to be adopted by other surgeons for assessment and comparison of results. The widespread use and reporting of consistent assessment methodologies will enable the community of RTKA surgeons to develop a better understanding of results, with greater external validity.

The telephone interview was chosen over a written or in-person assessment for a number of reasons. Firstly, we suggest that the quality of patient reporting outcomes is improved with discussion of outcomes as opposed to written reporting. We believe that written methods may be misinterpreted or not understood by patients, leading to erroneous results. The use of conversation to assess outcomes enables for clarification of questions when required. Secondly, we suggest that the use of telephone assessment places significantly less burden on the patient and the assessor in comparison to in-person review. The expectation placed on a patient to travel to a clinician's office for assessment may be unjustified and excessive, particularly for patients who may be geographically removed from their clinician, or may have mobility difficulties. Either or both of these factors can be expected in the RTKA patient population. Thirdly, we believe that based on the ease of contact and the short duration of time required to complete assessment, the use of telephone assessment enables a higher follow up rate by decreasing the burden on patients and clinicians alike.

The main potential negative of telephone assessment as opposed to written assessment is the opportunity for patients to feel pressured or coerced into providing a positive assessment of their outcome. We believe that this is more likely if the operating surgeon contacts the patient directly, and therefore another member of the team or an independent assessor could be utilized to prevent this occurrence. In our study, all patients were contacted by the primary investigator, and therefore patients had no direct contact with the treating team. Patients were also informed that their results would be de-identified and not

impact clinical care provided. We do acknowledge that phone assessment for PROMs has limitations, and that other avenues for assessment may be considered preferential by some clinicians or researchers.

The absence of clinical examination is a limitation of this research. It precludes the use of some knee arthroplasty scoring systems, and therefore our results are not directly comparable to some other authors or publications. The absence of radiographic assessment of implants is another limitation of this study. Similar to clinical assessment, its absence limits the direct comparison of our outcomes to other authors.
At time of study design we did consider the need for clinical assessment and radiographic assessment for this research. We believe that patient functional scores, such as the OKS, will be significantly affected by low range of motion or other clinical features of a poor outcome, and therefore it provides an indication of patient function and absence of significant limitations.

The ability for a patient to obtain a greater range of motion is overshadowed by the patient's ability or inability to complete activities of daily living. We believe that an important aspect of regular clinical assessment would be the identification of decreasing function, however we consider patients themselves or their general practitioner to be able to identify this and raise concerns appropriately.

We considered the addition of radiographic assessment in this research, but deemed it unnecessary and of significant burden to the patient. The time and cost involved in non-routine imaging that was not clinically indicated was considered to be greater than the benefit it would provide to the patient or this research. The additional risk of radiation exposure was also acknowledged. Therefore, it was not included in our study methodology. The senior author, Dr Randle, does however complete postoperative radiographs on second day after RTKA, and at 6 weeks, 12 weeks, or 3 months postoperatively, depending on bone graft or other augments utilized intraoperatively.
Dr Randle also requests for a patient to have radiographs arranged by their general practitioner at 5 yearly intervals postoperatively if asymptomatic, or earlier if any patient or general practitioner concerns. This facilitates the identification of periprosthetic complications radiographically and may prompt early referral. This remains a standard of

practice for Dr Randle, and we believe this is adequate to appropriately follow up patients radiographically.

The use of radiographic assessment would allow for preoperative identification of bone loss, which could be subsequently classified intraoperatively. This is a consideration for future research.

The use of a chart review for data collection is consistent with other retrospective orthopaedic research studies. This method enables accurate transcription of data directly from patient records to data analysis tools. Data recorded was obtained from written records made by Dr Randle in accordance with routine pre-operative, operative, post-operative, and follow up procedure.
The main limitation of the retrospective chart review process is the potential errors or absence of information which may be present within patient records. This was minimised by the meticulous nature of Dr Randle's record keeping. The potential for inter-observer error is eliminated by all patient assessment being performed by Dr Randle.

We expected a significant loss to follow up at the time of study design, due to the age of this patient cohort. Of the 178 patients identified from operative and surgical booking records, 137 were able to be contacted. The remaining 41 patients were lost due to death (27 patients) or inability to contact by telephone (14 patients). This loss to follow up of 23% is consistent with similar studies, and is an unfortunate reality of study design and patient cohort.
Other studies of similar design investigating medium to long term follow up of arthroplasty cohorts report similar loss to follow up. Nunez et al report follow up of 77% at 7 years in a primary TKA cohort.(261) Haleem et al reported a follow up of 66% at 7.2 years in a RTKA cohort.(262)

The results presented in this research lack robust external validity due to the study methodology of single surgeon, centre and implant used, which should be acknowledged before implementation into routine clinical practice for other surgeons. All patients underwent RTKA by an arthroplasty surgeon with over 30 years' experience in high volume knee arthroplasty. Dr Randle is involved in education of local orthopaedic registrars and fellows, as well as having significant experience in international educational

events. Dr Randle has also been involved in knee arthroplasty design and development. Therefore, with the experience, knowledge and high volume of RTKA procedures performed, these results will likely be superior to less experienced surgeons. The use of the PFC (Depuy) prosthesis has demonstrated high quality results over long term follow up.(13) Therefore, these results may be impacted by the prosthesis design and use, and may not be applicable to other prostheses. We do however acknowledge that multiple prostheses are available with similar long-term successful outcomes.
The patient cohort in this research included privately insured patients who were deemed medically fit for a RTKA procedure. These characteristics will not be applicable to all patients undergoing consideration of RTKA.

The impact of socioeconomic status on patient reported outcomes has been an area of recent investigation. Patients from lower income households report a lower satisfaction rate and greater functional limitations compared to higher socioeconomic groups.(263, 264) This may be an impacting factor within our cohort, as all patients were privately insured at time of surgery.

Due to the retrospective nature of this research and the study methodology employed, assessment and reporting of intraoperative bone loss was not possible. While bone loss is acknowledged as a contributing factor to postoperative outcomes and implant survival, the principles of zonal fixation were achieved intraoperatively through the use of necessary adjuncts.

8.4 Future directions

This research project has demonstrated a number of improvements which could be made to current clinical systems and research, to improve our understanding and management of RTKA.

RTKA requires further investigation to assess outcomes on a wider population level. While this research and other research into RTKA outcomes is helpful in developing an initial understanding, larger patient cohorts are required to reliably assess outcomes and factors which influence outcomes.

The national orthopaedic joint replacement registries are a valuable tool in assessing longevity of arthroplasty. Currently, the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) is considered a world leader in arthroplasty registry data capture. It does not however assess patient satisfaction or functional outcomes postoperatively. Conversely, the New Zealand Orthopaedic Association national arthroplasty registry does obtain functional scores postoperatively. The opportunity exists within the current AOANJRR framework to adopt a functional assessment tool which would have significant value in orthopaedic understanding worldwide.

There remains no consensus regarding methods to assess function or satisfaction postoperatively following RTKA. The selection of assessment tools for use as standardized methods would enable the comparison of outcomes between authors, implants, patient populations and national databases. This would facilitate an increased understanding of outcomes and establish common benchmarks for acceptable outcomes postoperatively. The current use of varied assessment methods prevents true comparison being made.

Prospective patient identification and assessment of outcomes at standardized time points is required for the orthopaedic community to improve understanding of outcomes following RTKA. The ideal system to monitor and critically assess outcomes would be multinational, multicenter, adopted by all surgeons undertaking RTKA procedures, utilising standardized preoperative, intraoperative, and postoperative assessment tools. A number of foreseeable challenges are evident in the establishment of such a system, however with the increasing use of technology and a common goal of RTKA surgeons to build such a database, the opportunity may soon exist.

The research methodology presented in this thesis could be utilized to design and implement a more rigorous research project investigating outcomes following RTKA. This project could be replicated with the addition of valuable improvements, such as follow up at regular time intervals postoperatively, completion of assessment tools at multiple time points, preoperative baseline assessment of greater detail, clinical examination at regular and latest follow up, and radiographic evaluation. Such a project would require considerable dedication and endurance to ensure appropriate data capture and meaningful results, however its benefits to the orthopaedic community would be significant and ongoing.

We are currently unaware of the development or alterations in satisfaction over time following RTKA. It may be that patients' satisfaction increases or decreases with increasing time postoperatively. Other factors which may have an influence on satisfaction postoperatively may include age, gender, pre-operative factors such as pain and functional ability, analgesia requirements, country of residence, or socioeconomic status. These potential contributing factors are able to be measured and assessed, but should be done in a structured way so as to ensure internal and external validity of the results.
Other factors which may impact patient satisfaction and functional outcomes include the personality, or character qualities, of the individual. Anecdotally, some patients seem to be more resilient, proactive and enthusiastic of the surgical process and rehabilitation demands, which we assume will result in better outcomes and satisfaction postoperatively. This however has not been investigated in this patient population. The future opportunities for research in this field are numerous, and may have a significant impact on orthopaedic care provision. The greater our understanding of factors which improve patient satisfaction, the more effectively we can provide care suited to the patients' specific needs and requests.

The appropriate selection of patient preoperatively is likely to become established through understanding postoperative results. Currently, patients who are deemed high risk must undergo extensive preoperative work up and optimization prior to operative intervention. This enables us, as clinicians, to ensure we are providing an intervention which is likely to benefit the patient. The question within clinical medicine is changing, from 'what can we do?' to 'what should we do?'

The patient perspective of RTKA is an area which would benefit from a more in-depth analysis and review. Patients' overall satisfaction is likely linked to numerous influencing factors, many of which are not explored in currently available quantitative assessment tools. The use of qualitative methods, although not traditionally used in assessing orthopaedic outcomes, may give greater insight and understanding into the personal influences on patients' outcomes and satisfaction postoperatively.

A holistic approach to patient outcomes and satisfaction will require involvement of a multidisciplinary team, with a focus on providing care for the individual, while avoiding a narrow scope of interest centered solely on the joint involved.
The emotional and practical concerns of patients vary between individuals, and therefore the expectations preoperatively and postoperatively also vary. By having a better understanding of the patient's goals, fears and expectations, care can be tailored to achieve a greater satisfaction postoperatively. This area for development is independent to surgical factors, and therefore provides potential for significant advances, whilst not relying on the surgeon as an individual.

In this qualitative assessment of patient experiences, no direction was given to the patients regarding topics for discussion. With the information obtained, a follow up questionnaire relating to identified themes and topics could be developed, and further assessment performed. With the development of a structured approach to patient perspective following RTKA, the change in satisfaction and patient perceptions over time could be investigated. It is likely that patient perspective in the immediate postoperative period would be significantly different from that of the same patient a number of years following surgery. It may also be possible to identify patients who are likely to be dissatisfied postoperatively, and thereby initiate strategies to best manage expectations and treatment options.

The opportunity for progress into understanding patient experience and perspective is an exciting area of future research. With increasing demands on clinicians to support the use of operative intervention, our goal will increasingly be to demonstrate improvements for patients, in quantitative and qualitative outcomes. Such an approach will drive us towards better outcomes for our patients as individuals, in a holistic, patient-centered and individualized approach to orthopaedic care.

The skill set required to achieve proficiency in RTKA takes significant time and opportunity to develop. It requires the opportunity to develop a thorough understanding of RTKA patients in general as well as the individual patient and their problem, and then develop a solution to address these issues.
Proficiency in RTKA is a valuable and highly regarded skill set, one which many orthopaedic surgeons set out to obtain.

The opportunity to develop this skill set requires regular exposure to RTKA cases, which is lacking for many surgeons. The nature of RTKA is such that it is much less common than primary TKA, and therefore the exposure that an individual surgeon has, and the ability to establish skills and overcome the surgical learning curve, is often a difficult hurdle. Furthermore, familiarity and proficiency with techniques and skills requires regular engagement of these attributes, and in a low volume clinical practice this may not be achievable.

The centralization of RTKA procedures is a concept which may be increasingly relevant in the coming years. With increasing demands being placed on healthcare systems, providing cost effective care to patients is of increasing importance.
Centralisation of RTKA procedures would also enable the training of orthopaedic surgeons in RTKA, and enable surgeons to gain increased understanding, skills and experience specific to RTKA surgery. This increased level of training would likely result in improved patient outcomes. Currently, some surgeons are utilizing opportunities of reverse visitation to engage with senior, experienced RTKA surgeons during complex cases. This is a valuable source of assistance for many surgeons, but could be improved by the provision of care in a specialized setting, with the active involvement of the referring surgeon. Such a setting would also provide opportunities for fellowship training in RTKA specifically, a subspecialisation which is likely to have increasing relevance and value in the future. Without focused opportunities to develop skills and experience in RTKA, many surgeons will require decades of individual surgical practice to obtain high numbers of RTKA cases. The volume of RTKA cases presented in this research may not be possible for other surgeons over their entire career. Therefore, an intentional approach and pursuit of opportunities in RTKA is required to ensure that surgeons with an interest in RTKA have adequate exposure and learning opportunities to develop this specific skill set. Failure to implement a program to provide such opportunities may result in a deficit of specific RTKA skills and experience within the local and broader Orthopaedic community when the current senior RTKA surgeons leave clinical practice.

Good patient outcomes and a low revision rate in our series adds support to the suggestion that establishing a service dedicated to complex RTKA could result in better patient outcomes when compared to the widespread distribution of this service amongst a large number of surgeons, each with a lower RTKA volume. This raises difficult issues for

orthopaedics locally and worldwide, but the ongoing focus must remain on better patient outcomes and appropriate stewardship of resources. Recently, Ricciardi et al published a review of outcomes for revision hip and knee arthroplasty, comparing high-volume centres with lower-volume centres. They concluded that concentrating revision surgery to higher-volume hospitals may reduce early complication rates and 90-day readmission rates.(265) Currently, there remains no consensus or quality research to determine the experience required to be considered competent in RTKA. This remains a difficult consideration for clinicians, researchers, and administrative personnel.

RTKA requires ongoing discussion and collaboration amongst experienced surgeons and other members of the team to expand the understanding of options and techniques which have proved successful for individuals. The sharing of individual outcomes will enable greater understanding of techniques which are effective for most surgeons, and therefore direct ongoing development and training in the use of these techniques.

Combined with development of understanding, skill and experience in RTKA is the need for further development and investigation into primary TKA. Consistently obtaining better patient outcomes and a lower complication rate following primary TKA will decrease the requirements for RTKA. Ongoing development at an individual surgeon and orthopaedic community level is required as we pursue higher quality outcomes for all patients.

8.5 My personal perspective

The undertaking of a research project of this magnitude has been a great challenge. It has required a concerted effort to develop knowledge, skills and experience in a variety of areas.

As a junior doctor aspiring to become an orthopaedic surgeon, my passion for orthopaedics and exposure to total knee arthroplasty provided a solid foundation of knowledge on which to build. The underlying principles and application of these principles is a part of my daily practice, and therefore the extension of this knowledge to incorporate revision arthroplasty and the finer details of knee arthroplasty was a welcome challenge. This project has prompted me to develop my understanding and knowledge of knee arthroplasty and revision arthroplasty, areas which I find interesting and exciting.

This research degree has also prompted me into an in-depth understanding of research principles and processes. Through this project I have developed a skill set which I believe will benefit me in the future as a clinician and researcher. As my research skills have developed, I have been able to use these transferable skills by involvement in other research projects and into my clinical practice. I am looking forward to future research projects and the ongoing development of high quality research skills.

A significant amount of time and effort has been required for the completion of this project. This process has enabled me to improve my time management skills, to better prioritise tasks, and to develop a drive towards efficiency and efficacy in both research and non-research endeavors.

When beginning this project, I envisioned it as an opportunity to contribute significantly to orthopaedic literature and build on understanding of revision total knee arthroplasty for myself and the wider orthopaedic community. It represented an ambitious task and a great challenge, in the hope of meaningful contributions to current understanding and literature. I believe that these aspirations have been achieved in this project, but the personal development which I have experienced through this process has been equally rewarding.

The process of qualitative assessment of patient outcomes has led me away from the common orthopaedic assessment approach. This has resulted in a significant change in my personal perspective of patient assessment. While not easily measured or understood, I believe that the patient perspective and experience following RTKA, or any surgical intervention, is of great importance. In my own practice, I hope to be able to incorporate some of my new understanding into developing qualitative assessment tools to direct preoperative discussion and ensure a shared understanding with my patients. I feel that this area of development will improve the doctor-patient relationship, enable appropriate expectation management, identify aspects of care significant for the individual patient, and therefore enable a tailored approach to orthopaedic care provision. In focusing my attention on the patient as an individual, I feel that I will be able to provide better care. I believe that a proactive, holistic approach can improve patient outcomes without changes to the surgical care provided. This research project has given me insight into the

multidimensional nature of patient care, prompting practical changes to improve patient satisfaction.

Throughout the process of this degree, I have been well supported by my research supervisors, my family, and friends. The completion of this project would not have been possible without their assistance and support. I would encourage others with a passion for clinical research to pursue a similar path in formal research-based education. It has been a challenging and rewarding undertaking.

CONCLUSIONS

We have demonstrated RTKA to be an effective procedure with a low revision rate, good functional outcomes, and high patient satisfaction.

This research contributes significantly to current understanding of RTKA patient outcomes, with a large patient cohort, mid to long term follow up, and clearly described, reproducible methods.

The application of this research to ongoing understanding and investigation of RTKA will support the assessment of patient satisfaction as an important outcome postoperatively. It provides other surgeons with a structured framework for assessing patient outcomes following RTKA surgery, and gives a benchmark of outcomes which can be achieved following RTKA.

The outcomes of this study enables clinicians to better inform patients regarding their likely postoperative outcomes following RTKA, thus facilitating better informed consent and open communication between clinicians and patients. It also assists clinicians in managing and ensuring appropriate patient expectations prior to undertaking RTKA surgery. The results support and enable better clinical decision making in regards to operative options following failure of primary TKA.

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Appendix 1 – Patient Information Sheet

Research Project: Long term outcomes following revision total knee arthroplasty

PATIENT INFORMATION SHEET

Dear Sir / Madam,

We are conducting a review of long term outcomes following revision of knee replacement surgery.
You have been identified from operative records at The Gold Coast Centre for Bone & Joint Surgery.

This review involves a short telephone interview, which will take approximately 10 minutes. The telephone interview involves completion of a questionnaire about your knee surgery by Dr Randle at John Flynn Hospital.

You can opt out of this research project, or decline to answer questionnaire sections, at any time.

Your individual results can be discussed with Dr Randle (Clinical Supervisor, Orthopaedic Surgeon) if you would like. He may then contact you directly if appropriate.

Following the telephone interview, we will review your clinical records at The Gold Coast Centre for Bone & Joint Surgery.

After data collection, your personal details will be removed from the research documents. Your personal details will not be disclosed to any third party.

This research study is being completed as a part of a Masters Degree at Bond University, under the supervision of Dr Ray Randle and Professor Peter Jones.

The total duration of the study is estimated to be 2 years. The duration of data collection is 6 months.

There are no financial implications for researchers, study participants, or other parties.

This research is likely to benefit the community by providing more information about the expected outcomes following revision total knee replacement. This will help both doctors and patients in understanding and discussing revision knee replacement surgery.

If you have any questions or concerns regarding this research project, please contact us directly. Contact details are listed below.

Kind Regards,

Dr Jonathan Quinn
Principle Investigator
Ph: (07) 5598 0094

Dr Ray Randle
Clinical Supervisor
Consultant Orthopaedic Surgeon
The Gold Coast Centre for Bone & Joint Surgery

Patient Information Sheet, Version 1, Developed 15/11/2015.

Appendix 2 – Patient Consent Form

Research Project: Long term outcomes following revision total knee arthroplasty

CONSENT FORM

Patient Name: …….

Patient Date of Birth: ……...

Contact telephone number: …….

1. I, the above named, hereby consent to my involvement in the above study.

2. I understand that participation in this study involves completion of a telephone interview / questionnaire, followed by a review of my records at The Gold Coast Centre for Bone & Joint Surgery by the study investigators.

3. I acknowledge that the nature, purpose and contemplated effects of the study so far as it affects me have been fully explained to me by the research worker and my consent is given voluntarily.

4. Although I understand that the purpose of this research project is to improve the quality of medical care, it has also been explained that my involvement may not be of any benefit to me.

5. I have been given the opportunity to have a member of my family or a friend present while the study was explained to me.

6. I am informed that no information regarding my medical history will be divulged and the results of any tests involving me will not be published so as to reveal my identity.

7. I understand that my involvement in the study will not affect my relationship with my medical advisers in their management of my health. I also understand that I am free to withdraw from the study at any stage without my future treatment being affected.

8. I give permission for the release of information regarding progress in this study to the study centre, on the understanding that while the study centre will keep confidential results under my name, no published study will identify me in any way.

9. I have been told that this study has been approved by the Ethics Committee at John Flynn Private Hospital / Bond University.

Verbal Consent obtained by:

- Dr Jonathan Quinn – Principle Investigator
- Other: ……

Signed: ……

Date: ……

Appendix 3 – Patient Telephone Interview Template

Research Project: Long term outcomes following revision total knee arthroplasty

patient questionnaire – Telephone interview

Patient name: ……

Patient Date of Birth: ……

Date of questionnaire completion: ……

Patient Alive and compos mentis (Yes / No):

Side of RTKA being investigated: Left □ Right □

Oxford Knee Score:

1) How would you describe the pain you usually have from your knee?	None Very mild Mild Moderate Severe
2) Have you had any trouble with washing and drying yourself (all over) because of your knee?	No trouble at all Very little trouble Moderate trouble Extreme difficulty Impossible to do
3) Have you had any trouble getting in and out of a car or using public transport because of your knee? (whichever you tend to use)	No trouble at all

	Very little trouble
	Moderate trouble
	Extreme difficulty
	Impossible to do
4) For how long have you been able to walk before the pain from your knee becomes severe? (with or without a stick)	No pain / >30 minutes
	16 to 30 minutes
	5 to 15 minutes
	Around the house only
	Not at all – severe on walking
5) After a meal (sat at a table), how painful has it been for you to stand up from a chair because of your knee?	Not at all painful
	Slightly painful
	Moderately painful
	Very painful
	Unbearable
6) Have you been limping when walking, because of your knee?	Rarely / never
	Sometimes or just at first
	Often, not just at first
	Most of the time
	All of the time

7) Could you kneel down and get up again afterwards?	Yes, easily
	With little difficulty
	With moderate difficulty
	With extreme difficulty
	No, impossible
8) Have you been troubled by pain from your knee in bed at night?	No nights
	Only 1 or 2 nights
	Some nights
	Most nights
	Every night
9) How much has pain from your knee interfered with your usual work (including housework)?	Not at all
	A little bit
	Moderately
	Greatly
	Totally
10) Have you felt that your knee might suddenly “give way” or let you down?	Rarely / never
	Sometimes or just at first
	Often, not just at first
	Most of the time
	All of the time
11) Could you do the household shopping on your own?	Yes, easily
	With little difficulty

With moderate difficulty
With extreme difficulty

No, impossible

12) Could you walk down a flight of stairs?

Yes, easily
With little difficulty
With moderate difficulty
With extreme difficulty
No, impossible

Total OKS Score: …….....

Would you have this operation (RTKA) again? Yes / No / Unsure

Would you have initial TKA and RTKA (All knee replacement operations) again?
Yes / No / Unsure

Patient Reported Satisfaction score (1→10, 1= poor, 10=excellent)……

Mahomed Satisfaction Scale (select one option for each question):

1 – How satisfied are you with the results of your surgery?
Very Satisfied / somewhat satisfied / somewhat dissatisfied / very dissatisfied

2 – How satisfied are you with the results of your surgery for improving pain?
Very Satisfied / somewhat satisfied / somewhat dissatisfied / very dissatisfied

3 – how satisfied are you with the results of your surgery for improving your ability to do home or yard work?

Very Satisfied / somewhat satisfied / somewhat dissatisfied / very dissatisfied

4 – how satisfied are you with the results of your surgery for improving your ability to do recreational activities?

Very Satisfied / somewhat satisfied / somewhat dissatisfied / very dissatisfied

Have you had any further surgery on this joint (post RTKA)? Yes / No

Was this procedure performed by Dr Randle? Yes / No

What was the date of this (further) procedure? ……

Patient Comments on experience of RTKA: ……..

……

……

Appendix 4 - Patient Chart Review Template

Research Project: Long term outcomes following revision total knee arthroplasty

Patient questionnaire – chart review

Patient name: ……

Patient Date of Birth: ……

Date of chart review completion: ……

Pre-operative Information –

Pre-op Oxford knee score:

Albumin pre-op:

Cause of failure of Primary TKA: Infection / Loosening / Lysis / stiffness / pain / PFJ pain / Other

Infection – organism grown on cultures:

Primary TKA performed by: Dr Randle / Other

Reason for primary TKA (OA / RA / Other):

Date of primary TKA:

No. of prior Revision TKAs of affected joint:

Pre-RTKA ROM:

Operative Information –

Date of RTKA operation:

Prosthesis model: PFC / Other

Prosthesis used: CR / PS

Polyethylene thickness (mm):

Type of primary prosthesis:

Cement used: Yes / No

Antibiotic cement used: Yes / No

Prosthesis parts cemented: Femur / tibia / patella

Stemmed implants used: Yes / No

Components with stemmed implants: Femur / tibia / both

Length of stem (mm):

Bone augments used: Yes / No

Artificial Augments used: Yes / No

Femur – Post condyle / Distal / Sleeve

Tibia – Medial / Lateral / Sleeve

Size of Augments used (mm):

Surgical Time (minutes):

Incision:

Extended Medial parapatella yes / no

TTO yes / no

Patient weight at time of surgery:

Patient BMI at time of surgery:

Patient ASA Score:

Diabetes: Yes / No

Smoking Status: Never / past / current

Post-operative Information –

Post-operative Haemoglobin (Hb) Day 1:

Blood transfusion required post-operatively: Yes / No

Number of units transfused:

Post-operative DVT prophylaxis: Mechanical / aspirin / clexane / heparin / warfarin / rivaroxaban

Duration of hospital stay (days):

Readmission within 30 days: yes / no

Readmission within 30 days for RTKA related cause: yes / no

Readmission within 90 days for RTKA related cause: Yes / no

Post-operative complications: Yes / No

Type of post-operative complication: SSI / DVT / MUA Required / deep infection / Other

Post RTKA ROM @ 3 months:

Post RTKA ROM @ 1 year:

Further surgery on RTKA joint (Failure of RTKA): Yes / No

Further surgery performed by: Dr Randle / Other

Date of further surgery:

Time to failure from RTKA procedure:

Cause of failure of RTKA:

Alive and competent: Yes / No

Date of death:

Time from RTKA to death:

Death related to RTKA: Yes / No

Appendix of statistical workings -
Data collected and format for statistical workings:
Patient characteristics:
Gender (Male = 1, Female = 2)
Patient date of birth
Patient age (years)
Patient age category (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Age at time of primary TKA (years)
Age category at time of primary OT (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
RTKA Operation date
Age at time of RTKA operation (years)
Age Category at time of RTKA (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Age at time of review (years)
Age category at time of review (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Time since RTKA at time of review (years)
Age category of time between RTKA and Review (2-5 years = 1, 5-10 years = 2, 10+ years = 3)

Pre-operative assessment:
Preoperative albumin
Patient weight (kgs)
Patient BMI
ASA score
Diabetic (No = 0, Yes = 1)
Diabetic type (1 or 2)
Diabetic management (Diet = 1, Oral agents = 2, Insulin = 3)
Smoking status (Never = 1, Past = 2, Current = 3)
Primary TKA Cause of Failure (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Instability, 7 = Other, 8 = progression of disease in UKA)
If infection – organism identified
Number of prior revisions
Pre RTKA ROM flexion (degrees)
Pre RTKA ROM extension (degrees)
Pre RTKA ROM total (degrees)

Intraoperative assessment:
Prosthesis type (CR = 1, PS = 2, TC3 = 3, Hinge = 4)
Polyethylene insert thickness (mm)
Cement used (No = 0, Yes = 1)
Prosthesis parts cemented (All = 1, Femur & Tibia = 2, femur alone = 3, tibia alone = 4, patella alone = 5, other combination = 6)
Stemmed implants used (No = 0, Yes = 1)
Components with stemmed implants (Femur and Tibia = 1, Femur alone =2, Tibia alone =3)
Femur stem length (mm)
Femur stem width (mm)
Tibial stem length (mm)
Tibial stem width (mm)
Bone augments used (No = 0, Yes = 1)

Location of bone graft / augment (Femur and Tibia = 1, Femur alone = 2, Tibia alone = 3)
Artificial augments used (No = 0, Yes = 1)
Size of augments used femur posterior condyle (mm)
Size of augment - femur distal (mm)
Size of augment - femoral sleeve (mm)
Size of augment - medial tibia (mm)
Size of augment - tibial sleeve (mm)
Surgical time (minutes)
Surgical Approach (Extended Medial Parapatella = 1, other = 2)
Tibial Tubercle Osteotomy required (No = 0, Yes = 1)

Perioperative assessment:
Post-operative (Day 1) haemoglobin
Blood transfusion required post-operatively (No = 0, Yes =1)
Number of units of blood transfusion given
Post op DVT prophylaxis - Mechanical (No = 0, Yes = 1)
Post op DVT prophylaxis - Chemical (Aspirin = 1, Clexane = 2, Heparin = 3, Warfarin = 4, Rivaroxiban = 5, Apixaban = 6, Clopidogrel = 7, Other = 8)
Duration of hospital stay total (days)
Duration of hospital stay under Orthopaedics (days)
Duration of hospital stay under Rehabilitation (days)

Post-operative outcomes assessment:
Oxford Knee Score (OKS)
3/12 (3 months) post RTKA ROM flexion (degrees)
3/12 (3 months) post RTKA ROM extension (degrees)
3/12 (3 months) post RTKA ROM total (degrees)
1 year post RTKA ROM flexion (degrees)
1 year post RTKA ROM extension (degrees)
1 year post RTKA ROM total (degrees)

Satisfaction assessment:
Would you have your RTKA again? (Yes = 1, Unsure = 2, No = 3)
Would you have your RTKA again? - Binary modification (Yes = 1 ,Unsure or No = 2)
Patient reported Score (1-10)
Mahomed Satisfaction Scale score

RTKA survivorship / postoperative complication assessment:
Readmission within 30 days (No = 0, Yes = 1)
Readmission within 30 days for RTKA cause (No = 0, Yes = 1)
Readmission within 90 days for RTKA related cause (No = 0, Yes = 1)
Post-operative complication (No = 0, Yes = 1)
Type of post-operative complication (SSI = 1, DVT =2, MUA required = 3, deep infection = 4, other = 5)
Failure of RTKA / Further surgery required (No = 0, Yes = 1)
Cause of failure of RTKA (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Other)

Descriptive statistics of patient age and gender

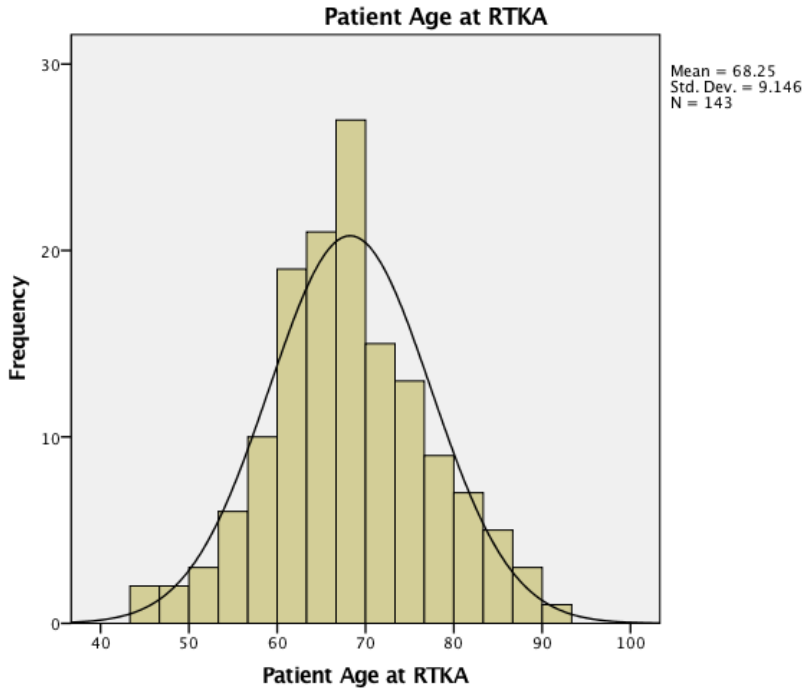
		Gender	Patient Age	Patient Age Category	Patient Age at RTKA	Patient Age Category at RTKA	Time since RTKA
N	Valid	143	143	143	143	143	143
	Missing	0	0	0	0	0	0
Mean		1.43	74.82	3.30	68.25	2.80	6.57
Median		1.00	74.00	3.00	67.73	3.00	6.22
Mode		1	63[a]	4	67[a]	3	3[a]
Std. Deviation		.497	8.870	.722	9.146	.885	3.082
Variance		.247	78.671	.522	83.647	.783	9.499
Skewness		.271	.158	-.753	.090	-.208	.409
Std. Error of Skewness		.203	.203	.203	.203	.203	.203
Range		1	49	3	45	3	11
Minimum		1	49	1	45	1	2
Maximum		2	98	4	90	4	13
Percentiles	25	1.00	68.85	3.00	61.93	2.00	3.76
	50	1.00	74.00	3.00	67.73	3.00	6.22
	75	2.00	81.11	4.00	74.17	3.00	9.11

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	81	56.6	56.6	56.6
	2	62	43.4	43.4	100.0
	Total	143	100.0	100.0	

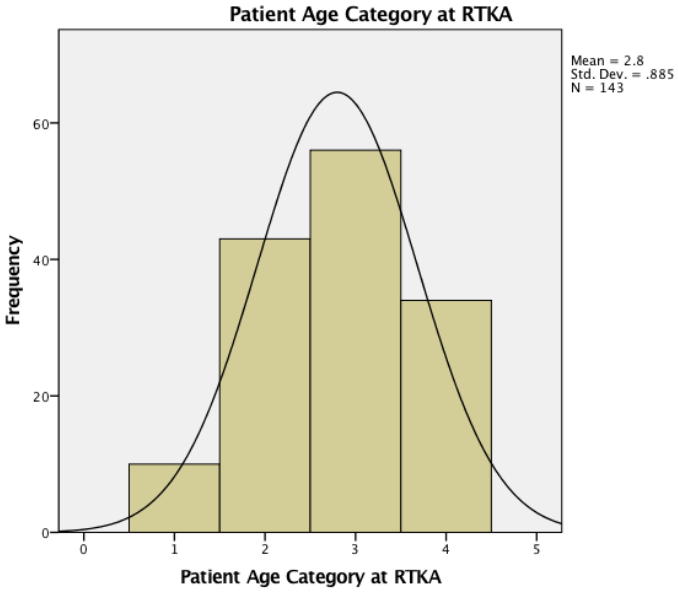
Patient Age Category

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	1.4	1.4	1.4
	2	16	11.2	11.2	12.6
	3	62	43.4	43.4	55.9
	4	63	44.1	44.1	100.0
	Total	143	100.0	100.0	



Patient Age Category at RTKA

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	10	7.0	7.0	7.0
	2	43	30.1	30.1	37.1
	3	56	39.2	39.2	76.2
	4	34	23.8	23.8	100.0
	Total	143	100.0	100.0	



Time Category Since RTKA

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	52	36.4	36.4	36.4
	2	70	49.0	49.0	85.3
	3	21	14.7	14.7	100.0
	Total	143	100.0	100.0	

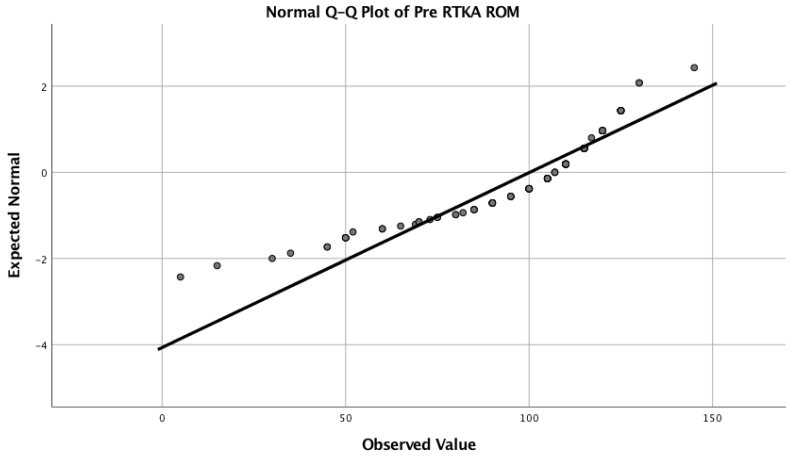
Distribution of outcome variables:

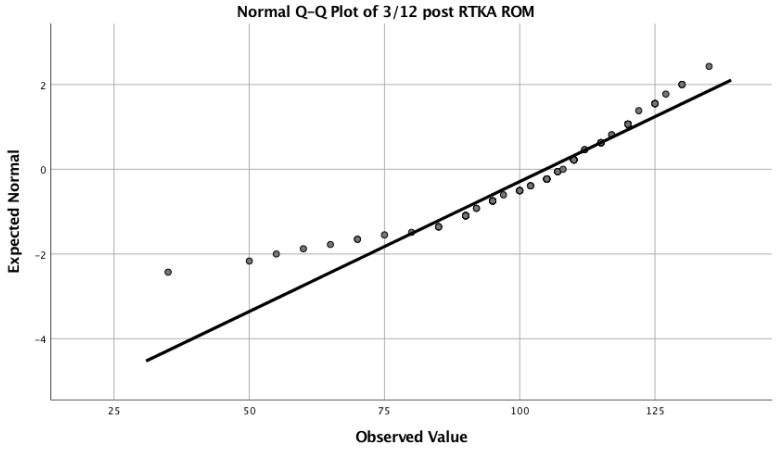
Key outcome variables were assessed for normality utilising visual (histograms, normal Q-Q plots) and statistical analysis (Shapiro-Wilk) methods, and found to be non-normally distributed. The data collected was markedly skewed, and therefore transformation was not able to restore the data to a normal distribution. Despite multiple transformation attempts, the obtained data sets still fail the formal test of normality. Therefore, we have adopted non-parametric analysis for these outcome measures.

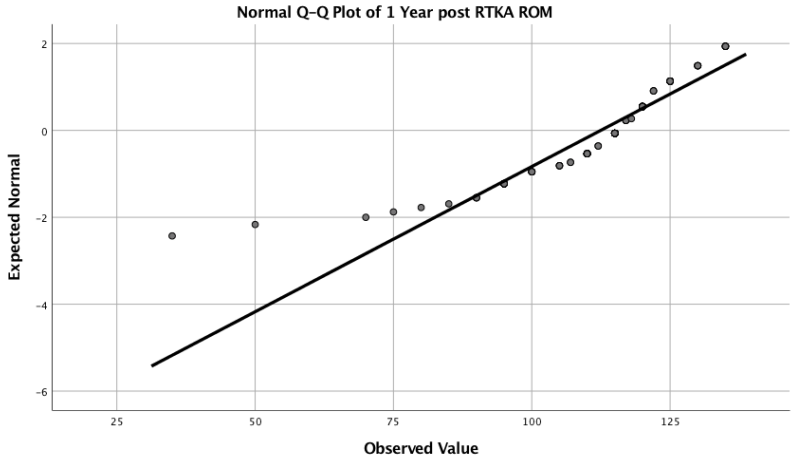
The use of non-parametric testing therefore includes Mann-Whitney test for two independent groups, Wilcoxon Signed Rank test for assessment of means of matched samples, Kruskal-Wallis test for means of three or more independent groups, Spearman Correlation Coefficient for relationship between continuous variables, and Chi-squared test for relationship between categorical variables.

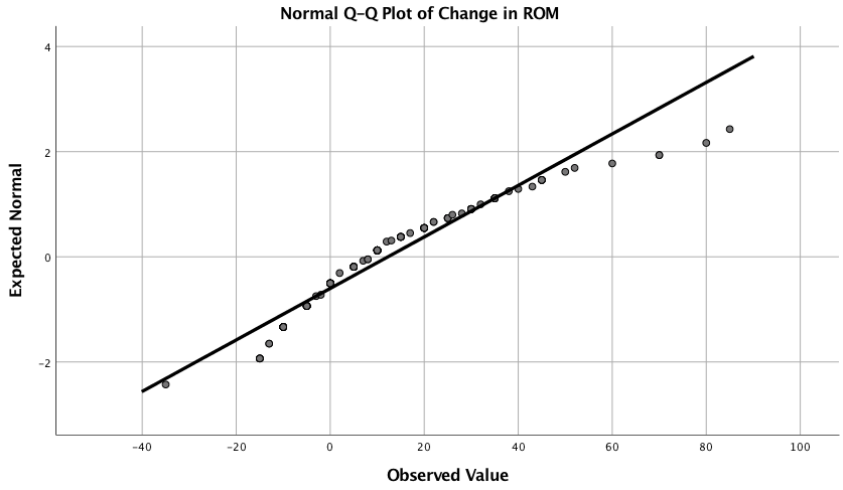
Tests of Normality

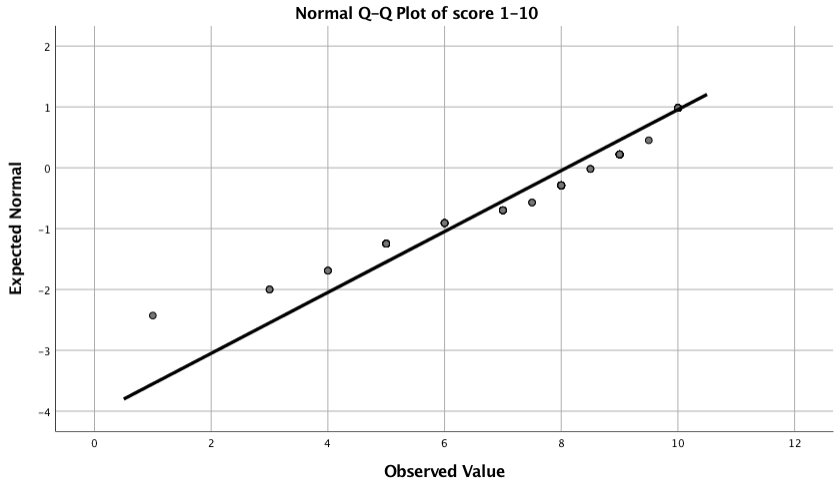
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre RTKA ROM	.192	131	.000	.860	131	.000
3/12 post RTKA ROM	.147	131	.000	.906	131	.000
1 Year post RTKA ROM	.201	131	.000	.839	131	.000
Change in ROM	.155	131	.000	.923	131	.000
RTKA again binary	.508	131	.000	.441	131	.000
score 1-10	.192	131	.000	.854	131	.000
MSS	.245	131	.000	.777	131	.000
Oxford Knee Score	.165	131	.000	.890	131	.000
Polyethylene Thickness (mm)	.202	131	.000	.872	131	.000
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	.263	131	.000	.842	131	.000

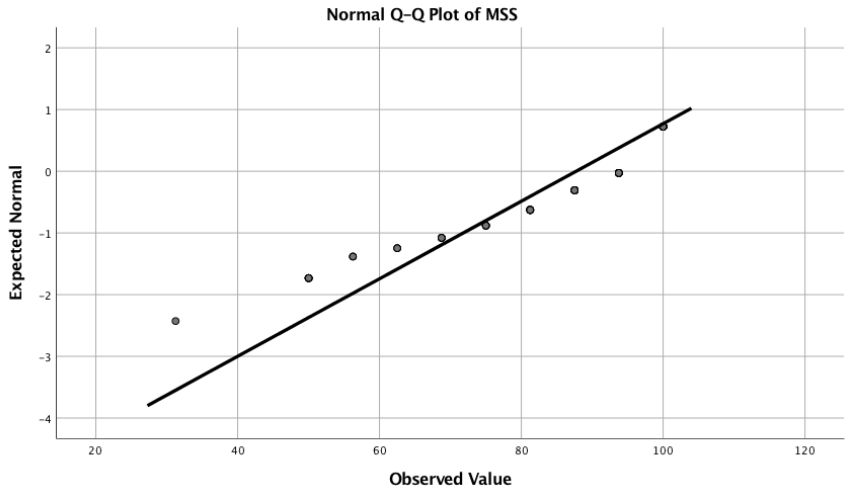

Normal Q–Q Plot of Pre RTKA ROM
Expected Normal
Observed Value
2
0
-2
-4
0
50
100
150

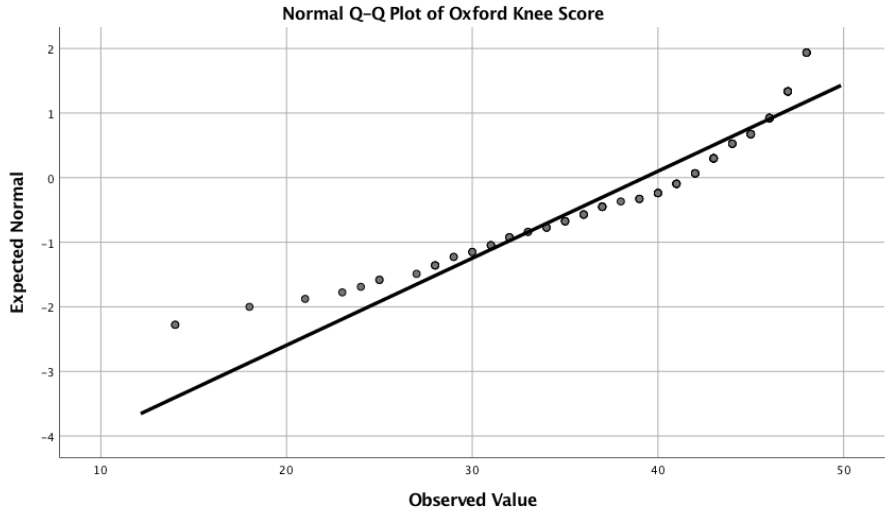

Normal Q–Q Plot of 3/12 post RTKA ROM
Expected Normal
Observed Value
2
0
-2
-4
25
50
75
100
125

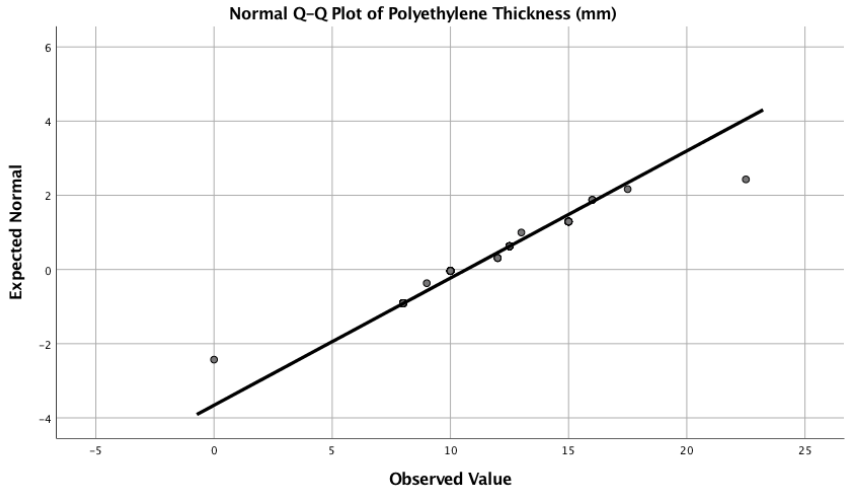

Normal Q–Q Plot of 1 Year post RTKA ROM
Expected Normal
Observed Value
2
0
-2
-4
-6
25
50
75
100
125

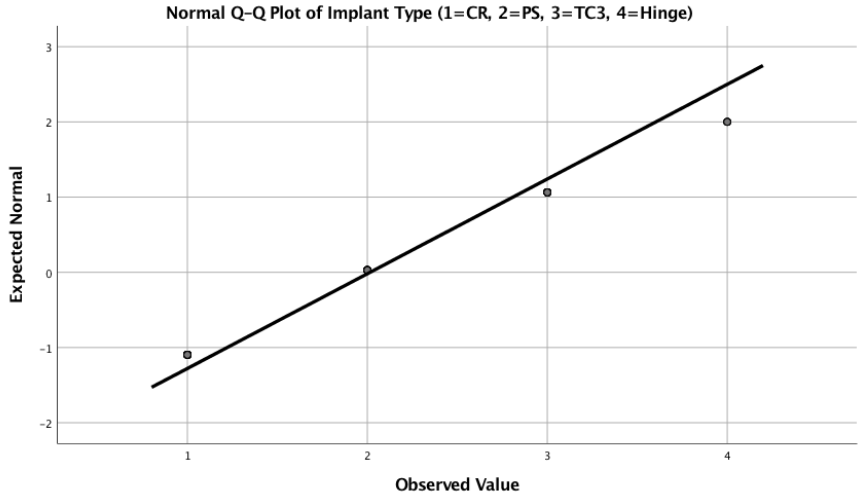

Normal Q-Q Plot of Change in ROM
Expected Normal
Observed Value
4
2
0
-2
-40
-20
0
20
40
60
80
100


Normal Q-Q Plot of score 1-10
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
0
2
4
6
8
10
12


Normal Q-Q Plot of MSS
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
20
40
60
80
100
120


Normal Q-Q Plot of Oxford Knee Score
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
10
20
30
40
50


Normal Q-Q Plot of Polyethylene Thickness (mm)
Expected Normal
Observed Value
6
4
2
0
-2
-4
-5
0
5
10
15
20
25


Normal Q-Q Plot of Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)
Expected Normal
Observed Value
3
2
1
0
-1
-2
1
2
3
4

Postoperative outcomes chapter statistical workings

The following data was collected and used for analysis of patient outcomes.
Preoperative:

- Gender (Male = 1, Female = 2)
- Patient age (years)
- Patient weight (kgs)
- Patient BMI
- Primary TKA Cause of Failure (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Instability, 7 = Other, 8 = progression of disease in UKA)
- Number of prior revisions
- Pre RTKA ROM total (degrees)

Intraoperative:

- Prosthesis type (CR = 1, PS = 2, TC3 = 3, Hinge = 4)
- Polyethylene insert thickness (mm)
- Stemmed implants used (No = 0, Yes = 1)
- Bone augments used (No = 0, Yes = 1)
- Artificial augments used (No = 0, Yes = 1)
- Surgical time (minutes)

Postoperative:

- Oxford Knee Score (OKS)
- 3 months post RTKA ROM total (degrees)
- 1 year post RTKA ROM total (degrees)
- Failure of RTKA / Further surgery required (No = 0, Yes = 1)
- Cause of failure of RTKA (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Other)

Oxford Knee Score:

Effect of Gender on OKS:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
OKS	143	39.25	7.434	14	48
Gender	143	1.43	.497	1	2

Mann-Whitney Test

Ranks

	Gender	N	Mean Rank	Sum of Ranks
OKS	1	81	79.01	6400.00
	2	62	62.84	3896.00
	Total	143		

Test Statistics[a]

	OKS
Mann-Whitney U	1943.000
Wilcoxon W	3896.000
Z	-2.319
Asymp. Sig. (2-tailed)	.020

a. Grouping Variable: Gender

Oxford Knee Score

Gender (M=1, F=2)	Mean	N	Std. Deviation
1	40.48	83	6.718
2	37.65	62	7.959
Total	39.27	145	7.384

Effect of age on OKS:

Correlations

			Oxford Knee Score	Patient Age
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	-.101
		Sig. (2-tailed)	.	.228
		N	145	145
	Patient Age	Correlation Coefficient	-.101	1.000
		Sig. (2-tailed)	.228	.
		N	145	153

Effect of Weight on OKS:

Correlations

			Oxford Knee Score	Patient Weight (kgs)
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	.150
		Sig. (2-tailed)	.	.081
		N	145	136
	Patient Weight (kgs)	Correlation Coefficient	.150	1.000
		Sig. (2-tailed)	.081	.
		N	136	143

Effect of BMI on OKS:

Correlations

			Oxford Knee Score	Patient BMI
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	-.087
		Sig. (2-tailed)	.	.314
		N	145	136
	Patient BMI	Correlation Coefficient	-.087	1.000
		Sig. (2-tailed)	.314	.
		N	136	143

Effect of previous RTKA procedures on OKS:

Correlations

			Oxford Knee Score	Number of Previous RTKAs
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	-.271**
		Sig. (2-tailed)	.	.001
		N	145	145
	Number of Previous RTKAs	Correlation Coefficient	-.271**	1.000
		Sig. (2-tailed)	.001	.
		N	145	153

Effect of pre-operative ROM on OKS:

Correlations

			Oxford Knee Score	Pre-RTKA ROM
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	.388**
		Sig. (2-tailed)	.	.000
		N	145	142
	Pre-RTKA ROM	Correlation Coefficient	.388**	1.000
		Sig. (2-tailed)	.000	.
		N	142	149

Effect of Cause of TKA failure on OKS:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
OKS	143	39.25	7.434	14	48
Cause of Failure of Primary TKA	143	3.73	2.556	1	8

Kruskal-Wallis Test

Ranks

	Cause of Failure of Primary TKA	N	Mean Rank
OKS	1	29	82.52
	2	49	65.90
	3	4	116.38
	4	10	71.15
	5	1	49.00
	6	13	57.12
	7	24	63.08
	8	13	91.65
	Total	143	

Test Statistics[a,b]

	OKS
Kruskal-Wallis H	13.616
df	7
Asymp. Sig.	.058

a. Kruskal Wallis Test

b. Grouping Variable: Cause of Failure of Primary TKA

Effect of implant type on OKS:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Oxford Knee Score	145	39.27	7.384	14	48
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	153	2.01	.827	1	4

Kruskal-Wallis Test

Ranks

	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	N	Mean Rank
Oxford Knee Score	1	41	91.50
	2	69	63.09
	3	28	80.50
	4	7	32.29
	Total	145	

Test Statistics[a,b]

	Oxford Knee Score
Kruskal-Wallis H	19.352
df	3
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)

Oxford Knee Score

Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	Mean	N	Std. Deviation
1	42.76	41	3.980
2	37.91	69	7.043
3	40.14	28	7.556
4	28.71	7	12.079
Total	39.27	145	7.384

Effect of Polyethylene thickness on OKS:

Correlations

			Oxford Knee Score	Polyethylene Thickness (mm)
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	-.068
		Sig. (2-tailed)	.	.415
		N	145	145
	Polyethylene Thickness (mm)	Correlation Coefficient	-.068	1.000
		Sig. (2-tailed)	.415	.
		N	145	153

Effect of Surgical time on OKS:

Correlations

			Oxford Knee Score	Surgical Time (minutes)
Spearman's rho	Oxford Knee Score	Correlation Coefficient	1.000	.031
		Sig. (2-tailed)	.	.720
		N	145	134
	Surgical Time (minutes)	Correlation Coefficient	.031	1.000
		Sig. (2-tailed)	.720	.
		N	134	140

3 month postoperative ROM:

Effect of gender on 3 month ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 3/12 Postoperatively	151	103.56	17.460	35	135
Gender (M=1, F=2)	153	1.44	.498	1	2

Mann-Whitney Test

Ranks

	Gender (M=1, F=2)	N	Mean Rank	Sum of Ranks
ROM 3/12 Postoperatively	1	84	77.27	6490.50
	2	67	74.41	4985.50
	Total	151		

Test Statistics[a]

	ROM 3/12 Postoperatively
Mann-Whitney U	2707.500
Wilcoxon W	4985.500
Z	-.401
Asymp. Sig. (2-tailed)	.689

a. Grouping Variable: Gender (M=1, F=2)

Effect of age on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Patient Age
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	.124
		Sig. (2-tailed)	.	.131
		N	151	151
	Patient Age	Correlation Coefficient	.124	1.000
		Sig. (2-tailed)	.131	.
		N	151	153

Effect of weight on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Patient Weight (kgs)
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	.087
		Sig. (2-tailed)	.	.302
		N	151	142
	Patient Weight (kgs)	Correlation Coefficient	.087	1.000
		Sig. (2-tailed)	.302	.
		N	142	143

Effect of BMI on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Patient BMI
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	.006
		Sig. (2-tailed)	.	.944
		N	151	142
	Patient BMI	Correlation Coefficient	.006	1.000
		Sig. (2-tailed)	.944	.
		N	142	143

Effect of previous RTKA on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Number of Previous RTKAs
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	-.073
		Sig. (2-tailed)	.	.370
		N	151	151
	Number of Previous RTKAs	Correlation Coefficient	-.073	1.000
		Sig. (2-tailed)	.370	.
		N	151	153

Effect of Reason for Revision on 3 month ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 3/12 Postoperatively	151	103.56	17.460	35	135
Reason For Revision	153	3.63	2.544	1	8

Kruskal-Wallis Test

Ranks

	Reason For Revision	N	Mean Rank
ROM 3/12 Postoperatively	1	34	61.40
	2	50	78.78
	3	5	14.30
	4	10	72.30
	5	1	91.00
	6	13	100.38
	7	25	88.72
	8	13	80.08
	Total	151	

Test Statistics[a,b]

	ROM 3/12 Postoperatively
Kruskal-Wallis H	20.595
df	7
Asymp. Sig.	.004

a. Kruskal Wallis Test

b. Grouping Variable: Reason For Revision

Effect of implant type on 3 month ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 3/12 Postoperatively	151	103.56	17.460	35	135
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	153	2.01	.827	1	4

Kruskal-Wallis Test

Ranks

	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	N	Mean Rank
ROM 3/12 Postoperatively	1	43	78.84
	2	72	72.35
	3	28	89.95
	4	8	44.75
	Total	151	

Test Statistics[a,b]

	ROM 3/12 Postoperatively
Kruskal-Wallis H	7.685
df	3
Asymp. Sig.	.053

a. Kruskal Wallis Test

b. Grouping Variable: Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)

Effect of Polyethylene thickness on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Polyethylene Thickness (mm)
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	.081
		Sig. (2-tailed)	.	.323
		N	151	151
	Polyethylene Thickness (mm)	Correlation Coefficient	.081	1.000
		Sig. (2-tailed)	.323	.
		N	151	153

Effect of Surgical time on 3 month ROM:

Correlations

			ROM 3/12 Postoperatively	Surgical Time (minutes)
Spearman's rho	ROM 3/12 Postoperatively	Correlation Coefficient	1.000	-.064
		Sig. (2-tailed)	.	.455
		N	151	139
	Surgical Time (minutes)	Correlation Coefficient	-.064	1.000
		Sig. (2-tailed)	.455	.
		N	139	140

1 year postoperative ROM:

Effect of Gender on 1 year ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 1 Year Postoperatively	151	110.66	16.452	35	135
Gender (M=1, F=2)	153	1.44	.498	1	2

Mann-Whitney Test

Ranks

	Gender (M=1, F=2)	N	Mean Rank	Sum of Ranks
ROM 1 Year Postoperatively	1	84	79.27	6658.50
	2	67	71.90	4817.50
	Total	151		

Test Statistics[a]

	ROM 1 Year Postoperatively
Mann-Whitney U	2539.500
Wilcoxon W	4817.500
Z	-1.037
Asymp. Sig. (2-tailed)	.300

a. Grouping Variable: Gender (M=1, F=2)

Effect of Age on 1 year ROM:

Correlations

			ROM 1 Year Postoperatively	Patient Age
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	-.010
		Sig. (2-tailed)	.	.905
		N	151	151
	Patient Age	Correlation Coefficient	-.010	1.000
		Sig. (2-tailed)	.905	.
		N	151	153

Effect of Weight on 1 year ROM:

Correlations

			ROM 1 Year Postoperatively	Patient Weight (kgs)
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	.141
		Sig. (2-tailed)	.	.094
		N	151	142
	Patient Weight (kgs)	Correlation Coefficient	.141	1.000
		Sig. (2-tailed)	.094	.
		N	142	143

Effect of BMI on 1 year ROM:

Correlations

			ROM 1 Year Postoperatively	Patient BMI
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	.011
		Sig. (2-tailed)	.	.893
		N	151	142
	Patient BMI	Correlation Coefficient	.011	1.000
		Sig. (2-tailed)	.893	.
		N	142	143

Effect of Previous RTKA on 1 year ROM:

Correlations

			ROM 1 Year Postoperatively	Number of Previous RTKAs
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	-.174*
		Sig. (2-tailed)	.	.032
		N	151	151
	Number of Previous RTKAs	Correlation Coefficient	-.174*	1.000
		Sig. (2-tailed)	.032	.
		N	151	153

*. Correlation is significant at the 0.05 level (2-tailed).

Effect of Reason for Revision on 1 year ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 1 Year Postoperatively	151	110.66	16.452	35	135
Reason For Revision	153	3.63	2.544	1	8

Kruskal-Wallis Test

Ranks

	Reason For Revision	N	Mean Rank
ROM 1 Year Postoperatively	1	34	62.26
	2	50	80.46
	3	5	27.70
	4	10	54.55
	5	1	79.00
	6	13	103.65
	7	25	84.76
	8	13	85.12
	Total	151	

Test Statistics[a,b]

	ROM 1 Year Postoperatively
Kruskal-Wallis H	19.479
df	7
Asymp. Sig.	.007

a. Kruskal Wallis Test

b. Grouping Variable: Reason For Revision

Effect of Implant type on 1 year ROM:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ROM 1 Year Postoperatively	151	110.66	16.452	35	135
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	153	2.01	.827	1	4

Kruskal-Wallis Test

Ranks

	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	N	Mean Rank
ROM 1 Year Postoperatively	1	43	81.73
	2	72	69.74
	3	28	88.86
	4	8	56.56
	Total	151	

Test Statistics[a,b]

	ROM 1 Year Postoperatively
Kruskal-Wallis H	6.324
df	3
Asymp. Sig.	.097

a. Kruskal Wallis Test

b. Grouping Variable: Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)

Effect of Polyethylene thickness on 1 year ROM:

Correlations

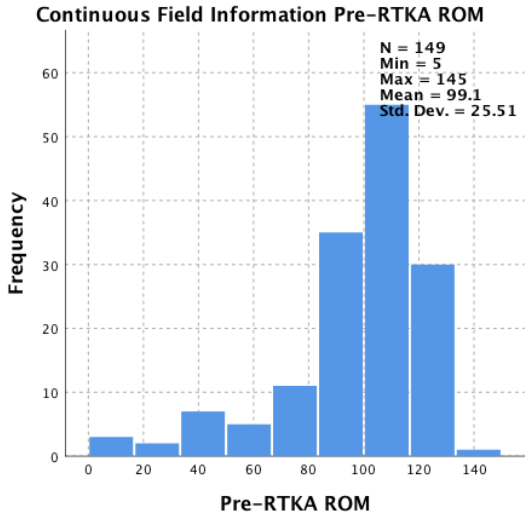
			ROM 1 Year Postoperatively	Polyethylene Thickness (mm)
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	.071
		Sig. (2-tailed)	.	.386
		N	151	151
	Polyethylene Thickness (mm)	Correlation Coefficient	.071	1.000
		Sig. (2-tailed)	.386	.
		N	151	153

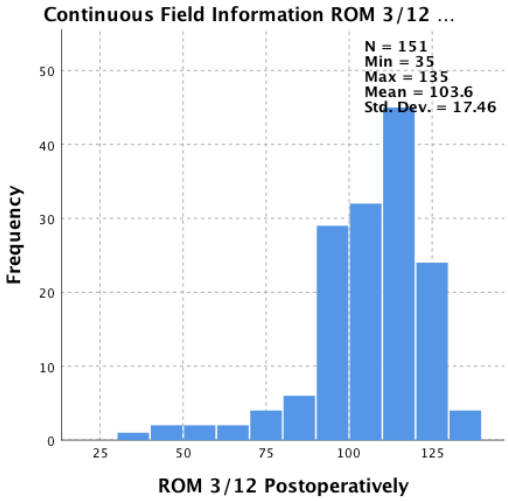
Effect of Surgical time on 1 year ROM:

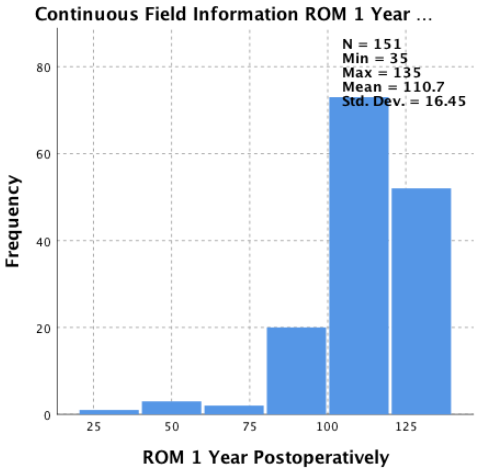
Correlations

			ROM 1 Year Postoperatively	Surgical Time (minutes)
Spearman's rho	ROM 1 Year Postoperatively	Correlation Coefficient	1.000	-.052
		Sig. (2-tailed)	.	.543
		N	151	139
	Surgical Time (minutes)	Correlation Coefficient	-.052	1.000
		Sig. (2-tailed)	.543	.
		N	139	140

ROM pre-operatively, at 3 months postoperative, and at 1 year postoperatively







Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Pre-RTKA ROM and ROM 3/12 Postoperatively equals 0.	Related-Samples Wilcoxon Signed Rank Test	.027	Reject the null hypothesis.

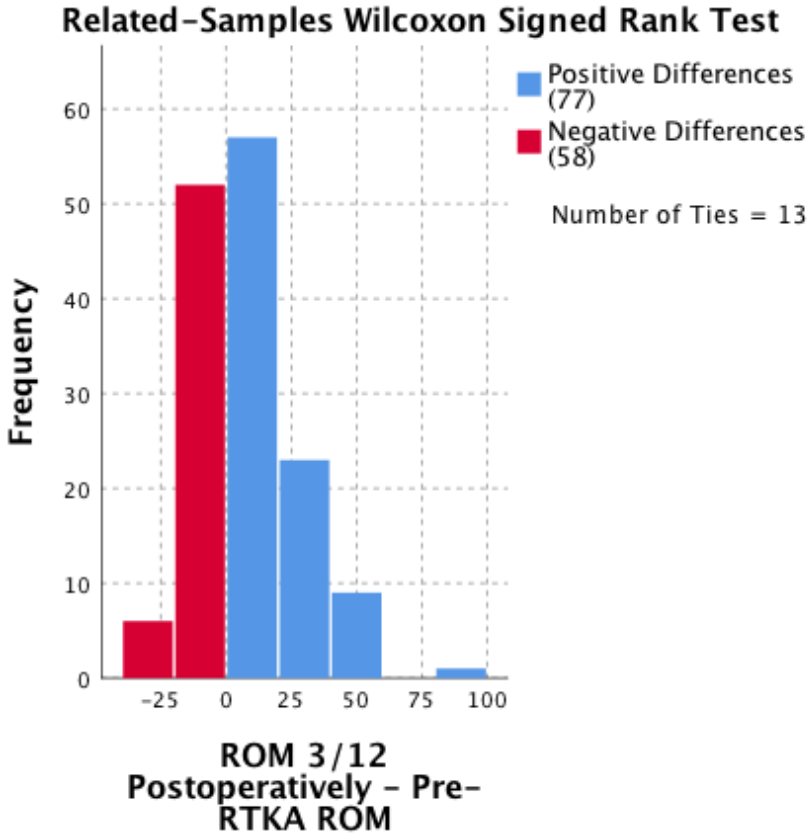
Asymptotic significances are displayed. The significance level is .050.

Related-Samples Wilcoxon Signed Rank Test

Pre-RTKA ROM, ROM 3/12 Postoperatively

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	148
Test Statistic	5592.500
Standard Error	453.989
Standardized Test Statistic	2.208
Asymptotic Sig.(2-sided test)	.027



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Pre-RTKA ROM and ROM 1 Year Postoperatively equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

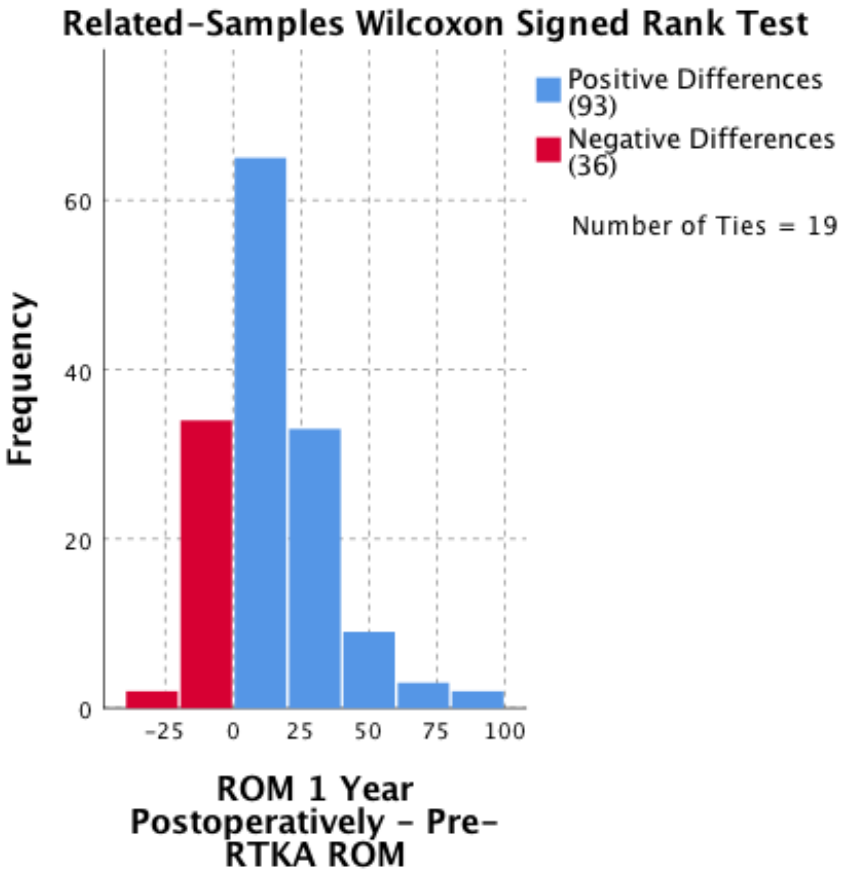
Asymptotic significances are displayed. The significance level is .050.

Related-Samples Wilcoxon Signed Rank Test

Pre-RTKA ROM, ROM 1 Year Postoperatively

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	148
Test Statistic	6924.500
Standard Error	424.368
Standardized Test Statistic	6.438
Asymptotic Sig.(2-sided test)	.000



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between ROM 3/12 Postoperatively and ROM 1 Year Postoperatively equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

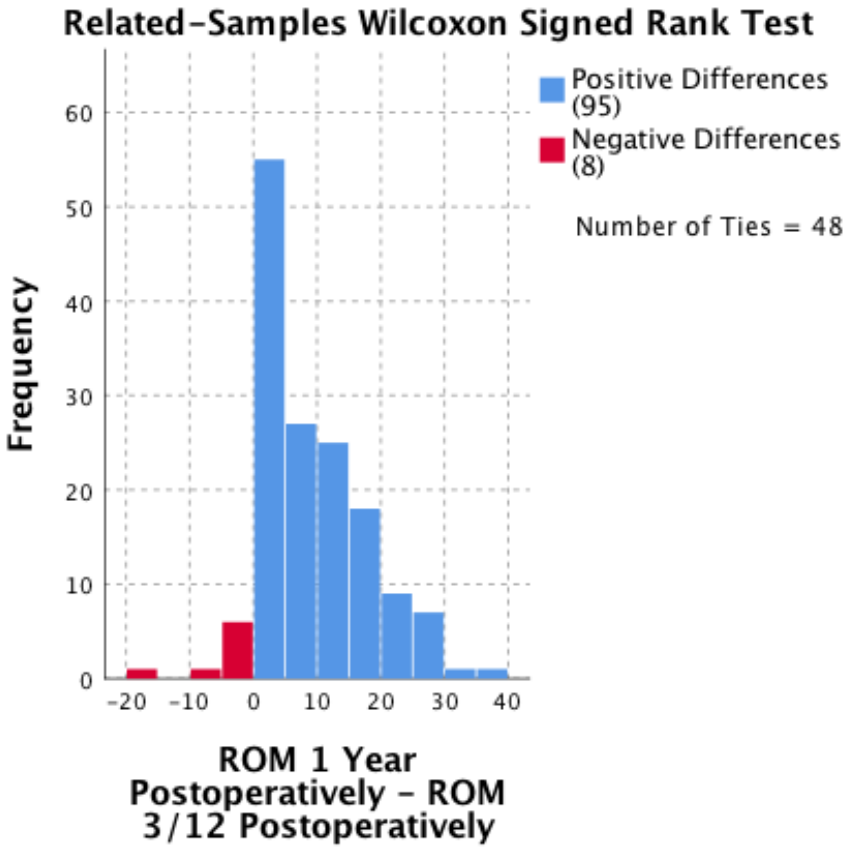
Asymptotic significances are displayed. The significance level is .050.

Related-Samples Wilcoxon Signed Rank Test

ROM 3/12 Postoperatively, ROM 1 Year Postoperatively

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	151
Test Statistic	5102.000
Standard Error	302.612
Standardized Test Statistic	8.010
Asymptotic Sig.(2-sided test)	.000



Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
ROM 3/12 Postoperatively - Pre-RTKA ROM	Negative Ranks	58[a]	61.85	3587.50
	Positive Ranks	77[b]	72.63	5592.50
	Ties	13[c]		
	Total	148		

a. ROM 3/12 Postoperatively < Pre-RTKA ROM

b. ROM 3/12 Postoperatively > Pre-RTKA ROM

c. ROM 3/12 Postoperatively = Pre-RTKA ROM

Test Statistics[a]

	ROM 3/12 Postoperatively - Pre-RTKA ROM
Z	-2.208[b]
Asymp. Sig. (2-tailed)	.027

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
ROM 1 Year Postoperatively - Pre-RTKA ROM	Negative Ranks	36[a]	40.57	1460.50
	Positive Ranks	93[b]	74.46	6924.50
	Ties	19[c]		
	Total	148		

a. ROM 1 Year Postoperatively < Pre-RTKA ROM

b. ROM 1 Year Postoperatively > Pre-RTKA ROM

c. ROM 1 Year Postoperatively = Pre-RTKA ROM

Test Statistics[a]

	ROM 1 Year Postoperatively - Pre-RTKA ROM
Z	-6.438[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
ROM 1 Year Postoperatively - ROM 3/12 Postoperatively	Negative Ranks	8[a]	31.75	254.00
	Positive Ranks	95[b]	53.71	5102.00
	Ties	48[c]		
	Total	151		

a. ROM 1 Year Postoperatively < ROM 3/12 Postoperatively

b. ROM 1 Year Postoperatively > ROM 3/12 Postoperatively

c. ROM 1 Year Postoperatively = ROM 3/12 Postoperatively

Test Statistics[a]

	ROM 1 Year Postoperatively - ROM 3/12 Postoperatively
Z	-8.010[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

RTKA Failure

Logistic Regression - Block 1: Method = Enter

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	33.255[a]	.149	.446

Classification Table[a]

			Predicted		
			RTKA Failure		
	Observed		0	1	Percentage Correct
Step 1	RTKA Failure	0	128	1	99.2
		1	5	2	28.6
	Overall Percentage				95.6

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Gender (M=1, F=2)(1)	-2.302	1.564	2.168	1	.141	.100
	Patient Age	.140	.076	3.340	1	.068	1.150
	Patient Weight (kgs)	-.035	.060	.352	1	.553	.965
	Patient BMI	.229	.183	1.560	1	.212	1.257
	Reason For Revision			1.396	7	.986	
	Reason For Revision(1)	18.590	9613.675	.000	1	.998	118478932.729
	Reason For Revision(2)	18.421	9613.675	.000	1	.998	100047292.721
	Reason For Revision(3)	19.927	9613.676	.000	1	.998	450902633.978
	Reason For Revision(4)	-.029	15044.154	.000	1	1.000	.972
	Reason For Revision(5)	-.246	41326.718	.000	1	1.000	.782
	Reason For Revision(6)	.660	13986.021	.000	1	1.000	1.935
	Reason For Revision(7)	16.999	9613.675	.000	1	.999	24140907.750
	Number of Previous RTKAs	-.931	.941	.980	1	.322	.394
	Pre-RTKA ROM	-.017	.030	.315	1	.575	.983
	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)			5.753	3	.124	
	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)(1)	-6.904	3.337	4.282	1	.039	.001
	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)(2)	-7.632	3.209	5.656	1	.017	.000
	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)(3)	-6.397	2.959	4.675	1	.031	.002
	Polyethylene Thickness (mm)	-.329	.232	2.009	1	.156	.720
	Surgical Time (minutes)	-.014	.018	.587	1	.443	.986
	Constant	-21.365	9613.679	.000	1	.998	.000

Effect of Pre-operative ROM on intraoperative factors:

Effect of Pre-operative ROM on use of stemmed implants:

Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	149	97.4
	Missing Cases	4	2.6
	Total	153	100.0
Unselected Cases		0	.0
Total		153	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
0	0
1	1

Block 0: Beginning Block

Classification Table[a,b]

			Predicted		
			Stemmed Implants (0=No, 1=Yes)		Percentage
	Observed		0	1	Correct
Step 0	Stemmed Implants (0=No, 1=Yes)	0	0	26	.0
		1	0	123	100.0
	Overall Percentage				82.6

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	1.554	.216	51.837	1	.000	4.731

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Pre-RTKA ROM	4.905	1	.027
	Overall Statistics		4.905	1	.027

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	6.139	1	.013
	Block	6.139	1	.013
	Model	6.139	1	.013

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	131.819[a]	.040	.067

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	8.965	7	.255

Contingency Table for Hosmer and Lemeshow Test

		Stemmed Implants (0=No, 1=Yes) = 0		Stemmed Implants (0=No, 1=Yes) = 1		
		Observed	Expected	Observed	Expected	Total
Step 1	1	7	5.105	11	12.895	18
	2	3	3.186	10	9.814	13
	3	3	4.215	16	14.785	19
	4	3	3.985	17	16.015	20
	5	2	2.879	14	13.121	16
	6	1	2.231	13	11.769	14
	7	3	2.255	14	14.745	17
	8	4	1.437	11	13.563	15
	9	0	.707	17	16.293	17

Classification Table[a]

			Predicted		
			Stemmed Implants (0=No, 1=Yes)		
	Observed		0	1	Percentage Correct
Step 1	Stemmed Implants (0=No, 1=Yes)	0	0	26	.0
		1	0	123	100.0
	Overall Percentage				82.6

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	Pre-RTKA ROM	-.027	.013	4.592	1	.032	.973	.949	.998
	Constant	4.385	1.388	9.980	1	.002	80.201		

a. Variable(s) entered on step 1: Pre-RTKA ROM.

Casewise List[b]

Case	Selected Status[a]	Observed Stemmed Implants (0=No, 1=Yes)	Predicted	Predicted Group	Temporary Variable Resid	ZResid	SResid
6	S	0**	.917	1	-.917	-3.317	-2.250
40	S	0**	.901	1	-.901	-3.015	-2.167
99	S	0**	.888	1	-.888	-2.817	-2.107
116	S	0**	.901	1	-.901	-3.015	-2.167
118	S	0**	.874	1	-.874	-2.632	-2.046
119	S	0**	.874	1	-.874	-2.632	-2.046

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

Effect of Pre-operative ROM on use of bone augments:

Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	149	97.4
	Missing Cases	4	2.6
	Total	153	100.0
Unselected Cases		0	.0
Total		153	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
0	0
1	1

Block 0: Beginning Block

Classification Table[a,b]

			Predicted		
			Bone Augments Used (0=No, 1=Yes)		
	Observed		0	1	Percentage Correct
Step 0	Bone Augments Used (0=No, 1=Yes)	0	84	0	100.0
		1	65	0	.0
	Overall Percentage				56.4

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-.256	.165	2.410	1	.121	.774

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Pre-RTKA ROM	5.691	1	.017
	Overall Statistics		5.691	1	.017

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	6.055	1	.014
	Block	6.055	1	.014
	Model	6.055	1	.014

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	198.073[a]	.040	.053

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	4.381	7	.735

Contingency Table for Hosmer and Lemeshow Test

		Bone Augments Used (0=No, 1=Yes) = 0		Bone Augments Used (0=No, 1=Yes) = 1		
		Observed	Expected	Observed	Expected	Total
Step 1	1	12	11.768	3	3.232	15
	2	11	11.219	6	5.781	17
	3	11	10.173	6	6.827	17
	4	10	7.910	4	6.090	14
	5	7	8.671	9	7.329	16
	6	8	10.439	12	9.561	20
	7	9	9.506	10	9.494	19
	8	8	6.235	5	6.765	13
	9	8	8.079	10	9.921	18

Classification Table[a]

			Predicted		
			Bone Augments Used (0=No, 1=Yes)		
	Observed		0	1	Percentage Correct
Step 1	Bone Augments Used (0=No, 1=Yes)	0	68	16	81.0
		1	50	15	23.1
	Overall Percentage				55.7

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	Pre-RTKA ROM	.017	.008	5.320	1	.021	1.017	1.003	1.033
	Constant	-1.996	.783	6.492	1	.011	.136		

a. Variable(s) entered on step 1: Pre-RTKA ROM.

Casewise List[b]

Case	Selected Status[a]	Observed Bone Augments Used (0=No, 1=Yes)	Predicted	Predicted Group	Temporary Variable Resid	ZResid	SResid
37	S	1**	.139	0	.861	2.487	2.049

a. S = Selected, U = Unselected cases, and ** = Misclassified cases.

b. Cases with studentized residuals greater than 2.000 are listed.

Effect of Pre-operative ROM on use of artificial augments: Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	149	97.4
	Missing Cases	4	2.6
	Total	153	100.0
Unselected Cases		0	.0
Total		153	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
0	0
1	1

Block 0: Beginning Block

Classification Table[a,b]

			Predicted		
			Artificial Augments used (0=No, 1=Yes)		
	Observed		0	1	Percentage Correct
Step 0	Artificial Augments used (0=No, 1=Yes)	0	0	66	.0
		1	0	83	100.0
	Overall Percentage				55.7

a. Constant is included in the model.

b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	.229	.165	1.931	1	.165	1.258

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Pre-RTKA ROM	5.155	1	.023
	Overall Statistics		5.155	1	.023

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	5.444	1	.020
	Block	5.444	1	.020
	Model	5.444	1	.020

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	199.170[a]	.036	.048

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.434	7	.385

Contingency Table for Hosmer and Lemeshow Test

		Artificial Augments used (0=No, 1=Yes) = 0		Artificial Augments used (0=No, 1=Yes) = 1		
		Observed	Expected	Observed	Expected	Total
Step 1	1	12	9.925	6	8.075	18
	2	8	6.792	5	6.208	13
	3	9	9.559	10	9.441	19
	4	9	9.656	11	10.344	20
	5	4	7.425	12	8.575	16
	6	5	6.194	9	7.806	14
	7	6	6.985	11	10.015	17
	8	8	5.372	7	9.628	15
	9	5	4.091	12	12.909	17

Classification Table[a]

			Predicted		
			Artificial Augments used (0=No, 1=Yes)		
	Observed		0	1	Percentage Correct
Step 1	Artificial Augments used (0=No, 1=Yes)	0	29	37	43.9
		1	21	62	74.7
	Overall Percentage				61.1

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	Pre-RTKA ROM	-.016	.007	4.850	1	.028	.984	.970	.998
	Constant	1.857	.767	5.858	1	.016	6.405		

a. Variable(s) entered on step 1: Pre-RTKA ROM.

Casewise List[a]

a. The casewise plot is not produced because no outliers were found.

Effect of pre-operative ROM on implant type:

Nominal Regression

Warnings

There are 63 (54.3%) cells (i.e., dependent variable levels by subpopulations) with zero frequencies.
The log-likelihood value cannot be further increased after maximum number of step-halving.
The NOMREG procedure continues despite the above warning(s). Subsequent results shown are based on the last iteration. Validity of the model fit is uncertain.

Case Processing Summary

		N	Marginal Percentage
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	1	41	27.5%
	2	72	48.3%
	3	28	18.8%
	4	8	5.4%
Pre-RTKA ROM	5	1	0.7%
	10	1	0.7%
	15	1	0.7%
	30	2	1.3%
	35	1	0.7%
	45	2	1.3%
	50	4	2.7%
	52	1	0.7%
	60	2	1.3%
	65	2	1.3%
	69	1	0.7%
	70	2	1.3%
	73	1	0.7%
	75	2	1.3%
	80	4	2.7%
	82	1	0.7%
	85	4	2.7%
	90	10	6.7%
	95	7	4.7%
	100	14	9.4%
	105	13	8.7%
	107	3	2.0%
	110	20	13.4%
	115	19	12.8%
	117	1	0.7%

	120	12	8.1%
	125	14	9.4%
	130	3	2.0%
	145	1	0.7%
Valid		149	100.0%
Missing		4	
Total		153	
Subpopulation		29[a]	

a. The dependent variable has only one value observed in 14 (48.3%) subpopulations.

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	161.107			
Final	95.702	65.405	84	.934

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	.000	0	.
Deviance	.000	0	.

Pseudo R-Square

Cox and Snell	.355
Nagelkerke	.393
McFadden	.186

Likelihood Ratio Tests

	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	95.702[a]	.000	0	.
Pre-RTKA ROM	161.107	65.405	84	.934

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Classification

Observed	Predicted 1	2	3	4	Percent Correct
1	27	11	3	0	65.9%
2	20	49	1	2	68.1%
3	6	15	6	1	21.4%
4	1	4	0	3	37.5%
Overall Percentage	36.2%	53.0%	6.7%	4.0%	57.0%

Effect of preoperative ROM on surgical time:

Correlations

			Pre-RTKA ROM	Surgical Time (minutes)
Spearman's rho	Pre-RTKA ROM	Correlation Coefficient	1.000	-.206*
		Sig. (2-tailed)	.	.016
		N	149	136
	Surgical Time (minutes)	Correlation Coefficient	-.206*	1.000
		Sig. (2-tailed)	.016	.
		N	136	140

*. Correlation is significant at the 0.05 level (2-tailed).

Effect of preoperative ROM on polyethylene thickness:

Correlations

			Pre-RTKA ROM	Polyethylene Thickness (mm)
Spearman's rho	Pre-RTKA ROM	Correlation Coefficient	1.000	-.180*
		Sig. (2-tailed)	.	.028
		N	149	149
	Polyethylene Thickness (mm)	Correlation Coefficient	-.180*	1.000
		Sig. (2-tailed)	.028	.
		N	149	153

*. Correlation is significant at the 0.05 level (2-tailed).

Effect of Stemmed implants / bone augments / artificial augments effect on Implant type:

Nominal Regression

Warnings

There are 6 (25.0%) cells (i.e., dependent variable levels by subpopulations) with zero frequencies.
Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.
The NOMREG procedure continues despite the above warning(s). Subsequent results shown are based on the last iteration. Validity of the model fit is uncertain.

Case Processing Summary

		N	Marginal Percentage
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	1	43	28.1%
	2	73	47.7%
	3	29	19.0%
	4	8	5.2%
Stemmed Implants (0=No, 1=Yes)	0	28	18.3%
	1	125	81.7%
Bone Augments Used (0=No, 1=Yes)	0	86	56.2%
	1	67	43.8%
Artificial Augments used (0=No, 1=Yes)	0	69	45.1%
	1	84	54.9%
Valid		153	100.0%
Missing		0	
Total		153	
Subpopulation		6[a]	

a. The dependent variable has only one value observed in 1 (16.7%) subpopulations.

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	130.356			
Final	40.326	90.030	9	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	3.433	6	.753
Deviance	5.017	6	.542

Pseudo R-Square

Cox and Snell	.445
Nagelkerke	.491
McFadden	.249

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	40.326[a]	.000	0	.
Stemmed Implants (0=No, 1=Yes)	56.308	15.982	3	.001
Bone Augments Used (0=No, 1=Yes)	45.727	5.401	3	.145
Artificial Augments used (0=No, 1=Yes)	73.898	33.572	3	.000

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Effect of Stemmed implants / bone augments / artificial augments effect on Surgical time:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Surgical Time (minutes)	140	146.74	37.591	60	315
Stemmed Implants (0=No, 1=Yes)	153	.82	.388	0	1

Kruskal-Wallis Test

Ranks

	Stemmed Implants (0=No, 1=Yes)	N	Mean Rank
Surgical Time (minutes)	0	24	26.75
	1	116	79.55
	Total	140	

Test Statistics[a,b]

	Surgical Time (minutes)
Kruskal-Wallis H	33.729
df	1
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Stemmed Implants (0=No, 1=Yes)

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Surgical Time (minutes)	140	146.74	37.591	60	315
Bone Augments Used (0=No, 1=Yes)	153	.44	.498	0	1

Kruskal-Wallis Test

Ranks

	Bone Augments Used (0=No, 1=Yes)	N	Mean Rank
Surgical Time (minutes)	0	79	69.65
	1	61	71.61
	Total	140	

Test Statistics[a,b]

	Surgical Time (minutes)
Kruskal-Wallis H	.081
df	1
Asymp. Sig.	.777

a. Kruskal Wallis Test

b. Grouping Variable: Bone Augments Used (0=No, 1=Yes)

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Surgical Time (minutes)	140	146.74	37.591	60	315
Artificial Augments used (0=No, 1=Yes)	153	.55	.499	0	1

Kruskal-Wallis Test

Ranks

	Artificial Augments used (0=No, 1=Yes)	N	Mean Rank
Surgical Time (minutes)	0	58	44.81
	1	82	88.67
	Total	140	

Test Statistics[a,b]

	Surgical Time (minutes)
Kruskal-Wallis H	39.758
df	1
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Artificial Augments used (0=No, 1=Yes)

Effect of implant type on surgical time:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Surgical Time (minutes)	140	146.74	37.591	60	315
Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	153	2.01	.827	1	4

Kruskal-Wallis Test

Ranks

	Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	N	Mean Rank
Surgical Time (minutes)	1	38	43.20
	2	67	75.09
	3	29	89.00
	4	6	102.75
	Total	140	

Test Statistics[a,b]

	Surgical Time (minutes)
Kruskal-Wallis H	27.926
df	3
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)

Assessment of normality for Surgical Time data:

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Surgical Time (minutes)	140	91.5%	13	8.5%	153	100.0%

Descriptives

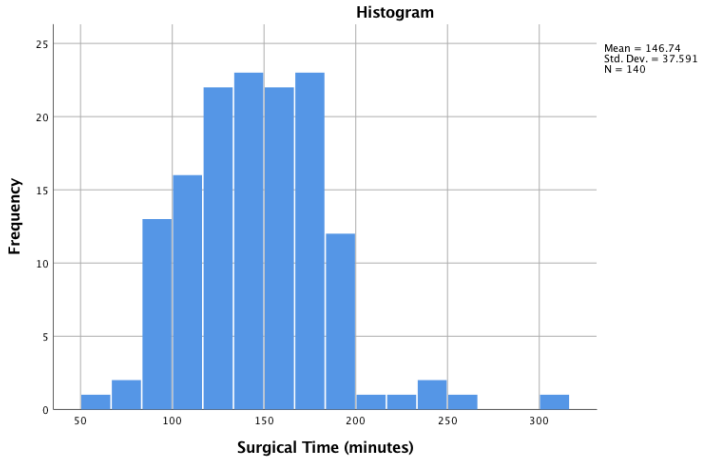
			Statistic	Std. Error
Surgical Time (minutes)	Mean		146.74	3.177
	95% Confidence Interval for Mean	Lower Bound	140.46	
		Upper Bound	153.02	
	5% Trimmed Mean		145.13	
	Median		144.50	
	Variance		1413.056	
	Std. Deviation		37.591	
	Minimum		60	
	Maximum		315	
	Range		255	
	Interquartile Range		51	
	Skewness		.808	.205
	Kurtosis		2.320	.407

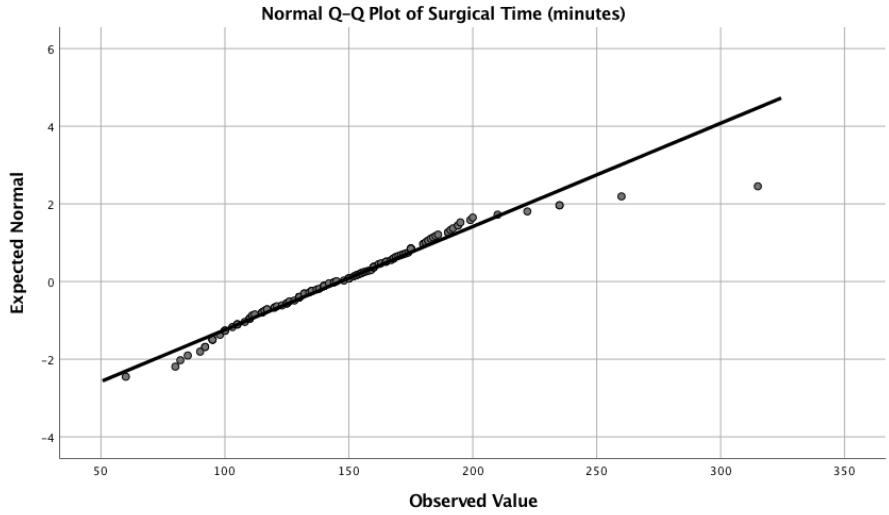
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Surgical Time (minutes)	.055	140	.200*	.961	140	.001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction


Histogram
Mean = 146.74
Std. Dev. = 37.591
N = 140
Frequency
Surgical Time (minutes)


Normal Q-Q Plot of Surgical Time (minutes)
Expected Normal
Observed Value

Effect of Previous RTKAs on implant type:

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Number of Previous RTKAs * Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	153	100.0%	0	0.0%	153	100.0%

Number of Previous RTKAs * Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge) Crosstabulation

			Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)				
			1	2	3	4	Total
Number of Previous RTKAs	0	Count	41	55	27	4	127
		% within Number of Previous RTKAs	32.3%	43.3%	21.3%	3.1%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	95.3%	75.3%	93.1%	50.0%	83.0%
		% of Total	26.8%	35.9%	17.6%	2.6%	83.0%
	1	Count	2	13	1	2	18
		% within Number of Previous RTKAs	11.1%	72.2%	5.6%	11.1%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	4.7%	17.8%	3.4%	25.0%	11.8%
		% of Total	1.3%	8.5%	0.7%	1.3%	11.8%
	2	Count	0	3	1	1	5
		% within Number of Previous RTKAs	0.0%	60.0%	20.0%	20.0%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	0.0%	4.1%	3.4%	12.5%	3.3%
		% of Total	0.0%	2.0%	0.7%	0.7%	3.3%
	3	Count	0	1	0	1	2
		% within Number of Previous RTKAs	0.0%	50.0%	0.0%	50.0%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	0.0%	1.4%	0.0%	12.5%	1.3%
		% of Total	0.0%	0.7%	0.0%	0.7%	1.3%
	4	Count	0	1	0	0	1
		% within Number of Previous RTKAs	0.0%	100.0%	0.0%	0.0%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	0.0%	1.4%	0.0%	0.0%	0.7%
		% of Total	0.0%	0.7%	0.0%	0.0%	0.7%
Total		Count	43	73	29	8	153
		% within Number of Previous RTKAs	28.1%	47.7%	19.0%	5.2%	100.0%
		% within Implant Type (1=CR, 2=PS, 3=TC3, 4=Hinge)	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	28.1%	47.7%	19.0%	5.2%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	23.083[a]	12	.027
Likelihood Ratio	20.736	12	.054
Linear-by-Linear Association	4.915	1	.027
N of Valid Cases	153		

a. 14 cells (70.0%) have expected count less than 5. The minimum expected count is .05.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.388	.027
	Cramer's V	.224	.027
N of Valid Cases		153	

Patient Satisfaction Chapter - Methods / Analysis / Results

Data collected and considered for analysis:

Patient characteristics:
Gender (Male = 1, Female = 2)
Patient age (years)
Patient age category (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Age at time of RTKA operation (years)
Age Category at time of RTKA (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Age at time of review (years)
Age category at time of review (as per AOANJRR) (<55 = 1, 55-64 = 2, 65-74 = 3, 75+ = 4)
Time since RTKA at time of review (years)
Age category of time between RTKA and Review (2-5 years = 1, 5-10 years = 2, 10+ years = 3)

Pre-operative assessment:
Patient weight (kgs)
Patient BMI
ASA score
Diabetic (No = 0, Yes = 1)
Diabetic type (1 or 2)
Diabetic management (Diet = 1, Oral agents = 2, Insulin = 3)
Smoking status (Never = 1, Past = 2, Current = 3)
Primary TKA Cause of Failure (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Instability, 7 = Other, 8 = progression of disease in UKA)
If infection – organism identified
Number of prior revisions
Pre RTKA ROM total (degrees)

Intraoperative assessment:
Prosthesis type (CR = 1, PS = 2, TC3 = 3, Hinge = 4)
Polyethylene insert thickness (mm)
Surgical time (minutes)
Surgical Approach (Extended Medial Parapatella = 1, other = 2)
Tibial Tubercle Osteotomy required (No = 0, Yes = 1)

Perioperative assessment:

Blood transfusion required post-operatively (No = 0, Yes =1)
Duration of hospital stay total (days)
Duration of hospital stay under Orthopaedics (days)
Duration of hospital stay under Rehabilitation (days)

Post-operative outcomes assessment:
Oxford Knee Score (OKS)
3/12 (3 months) post RTKA ROM total (degrees)
1 year post RTKA ROM total (degrees)

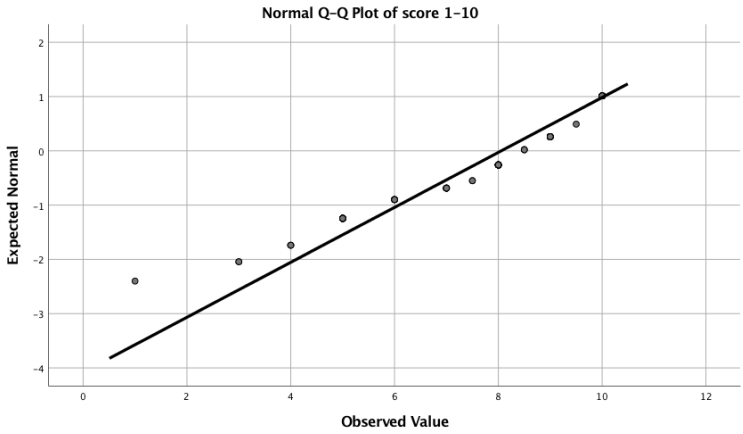
RTKA survivorship / postoperative complication assessment:
Readmission within 30 days for RTKA cause (No = 0, Yes = 1)
Readmission within 90 days for RTKA related cause (No = 0, Yes = 1)
Post-operative complication (No = 0, Yes = 1)
Type of post-operative complication (SSI = 1, DVT =2, MUA required = 3, deep infection = 4, other = 5)
Failure of RTKA / Further surgery required (No = 0, Yes = 1)

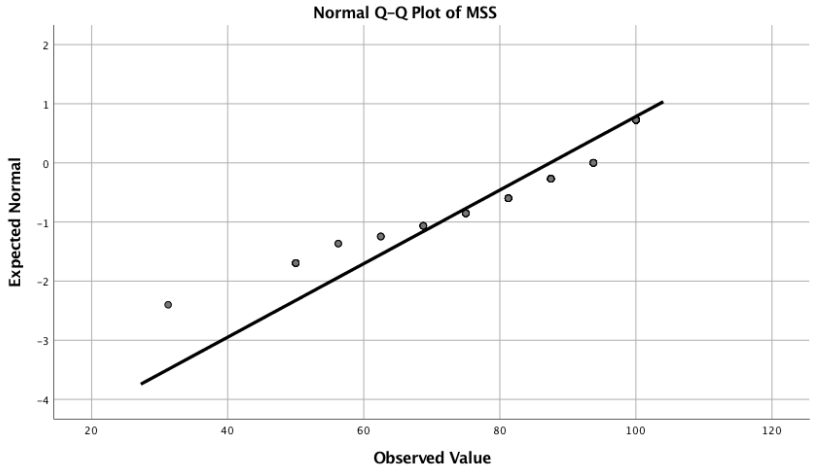
Satisfaction assessment:
Would you have your RTKA again? (Yes = 1, Unsure = 2, No = 3)
Would you have your RTKA again? - Binary modification (Yes = 1 ,Unsure or No = 2)
Patient reported Score (1-10)
Mahomed Satisfaction Scale

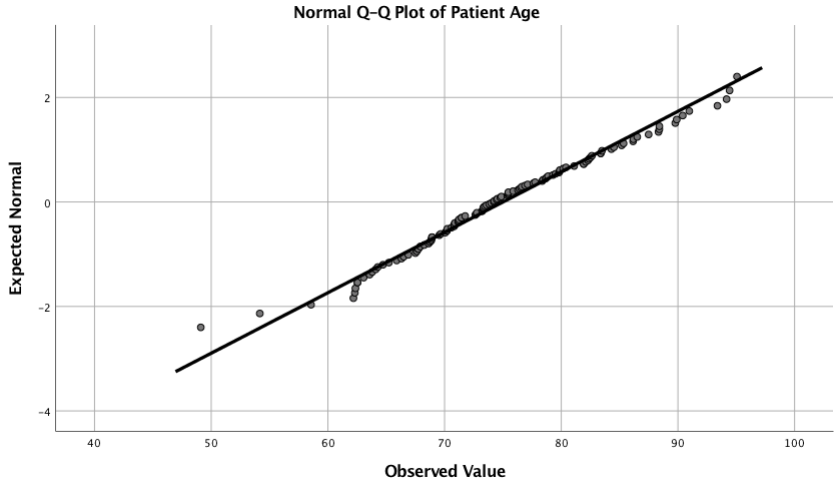
Distribution / normality of outcome data:

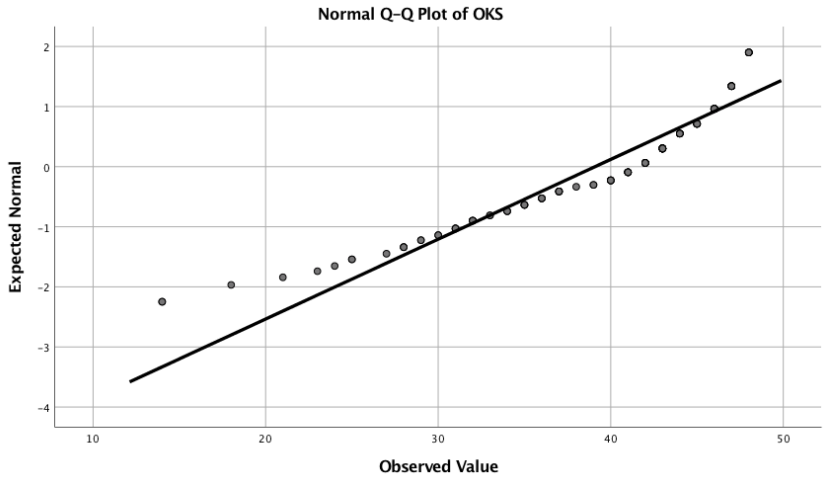
Tests of Normality

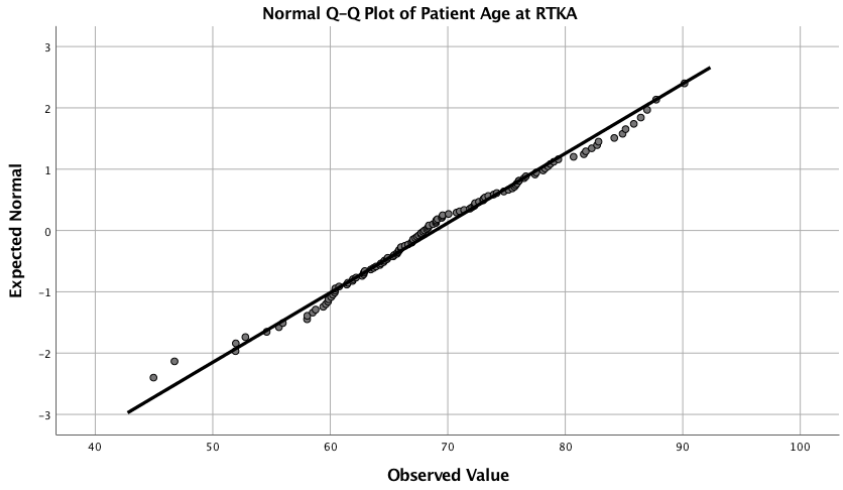
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
score 1-10	.191	121	.000	.862	121	.000
MSS	.246	121	.000	.784	121	.000
Patient Age	.058	121	.200*	.989	121	.422
OKS	.170	121	.000	.892	121	.000
Patient Age at RTKA	.075	121	.095	.990	121	.561
Time since RTKA	.095	121	.010	.952	121	.000
Age at time of primary TKA	.074	121	.162	.976	121	.032
Pre RTKA ROM	.193	121	.000	.855	121	.000
3/12 post RTKA ROM	.136	121	.000	.911	121	.000
1 Year post RTKA ROM	.200	121	.000	.834	121	.000
Change in ROM	.169	121	.000	.902	121	.000
Duration of Hospital Stay	.346	121	.000	.616	121	.000
Post-op Haemoglobin	.075	121	.092	.976	121	.030
Patient Weight	.086	121	.028	.976	121	.029
Patient BMI	.123	121	.000	.978	121	.047
Surgical Time	.060	121	.200*	.984	121	.156

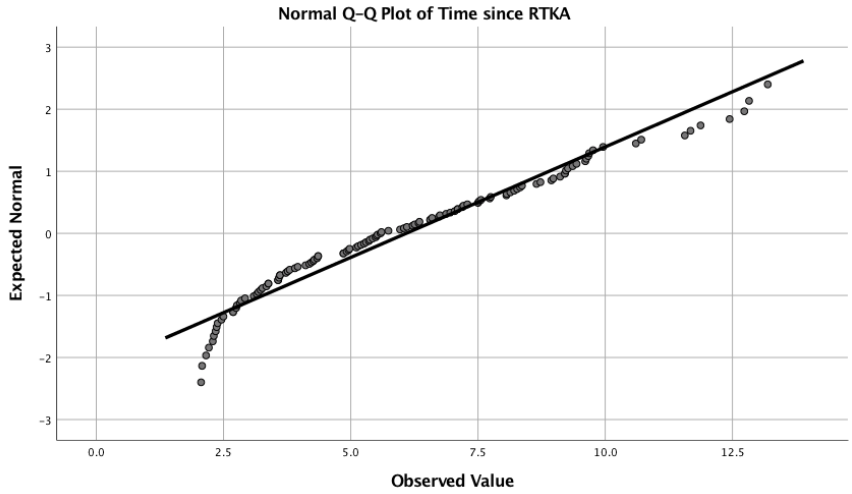


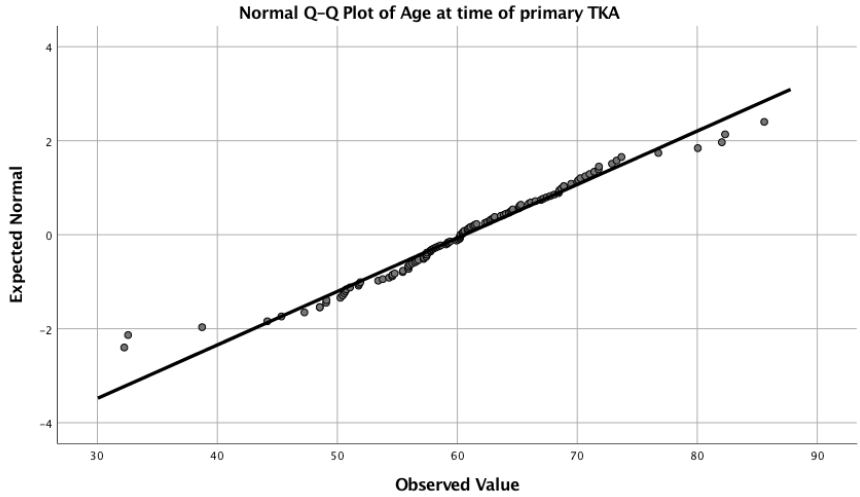

Normal Q-Q Plot of MSS
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
20
40
60
80
100
120

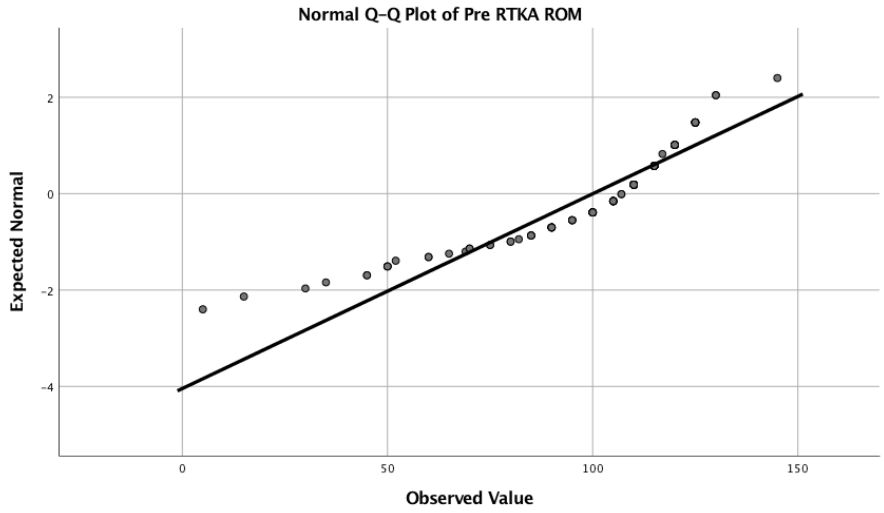

Normal Q-Q Plot of Patient Age
Expected Normal
Observed Value
2
0
-2
-4
40
50
60
70
80
90
100

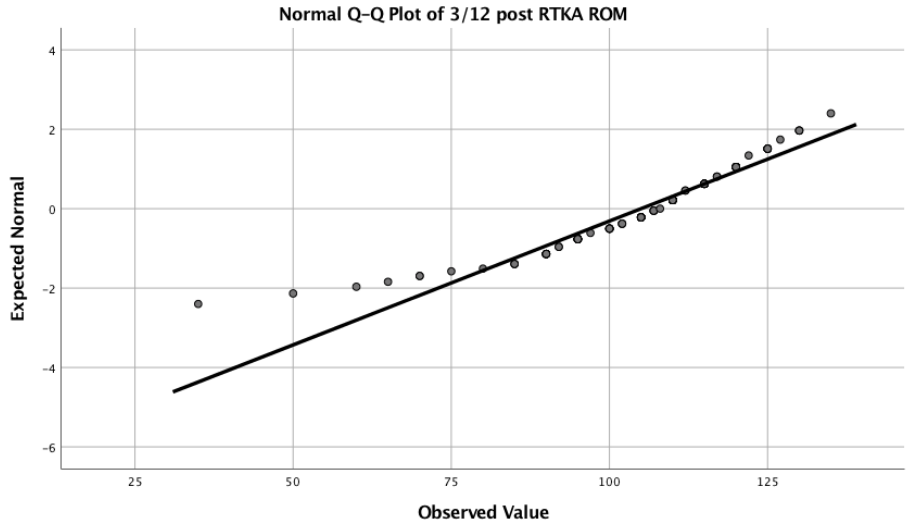

Normal Q-Q Plot of OKS
Expected Normal
Observed Value
2
1
0
-1
-2
-3
-4
10
20
30
40
50

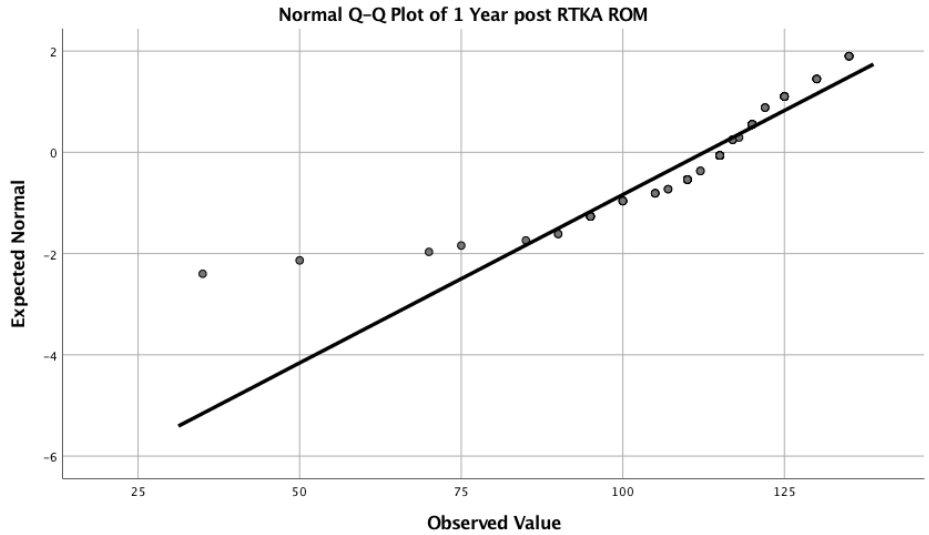

Normal Q–Q Plot of Patient Age at RTKA
Expected Normal
Observed Value
3
2
1
0
−1
−2
−3
40
50
60
70
80
90
100

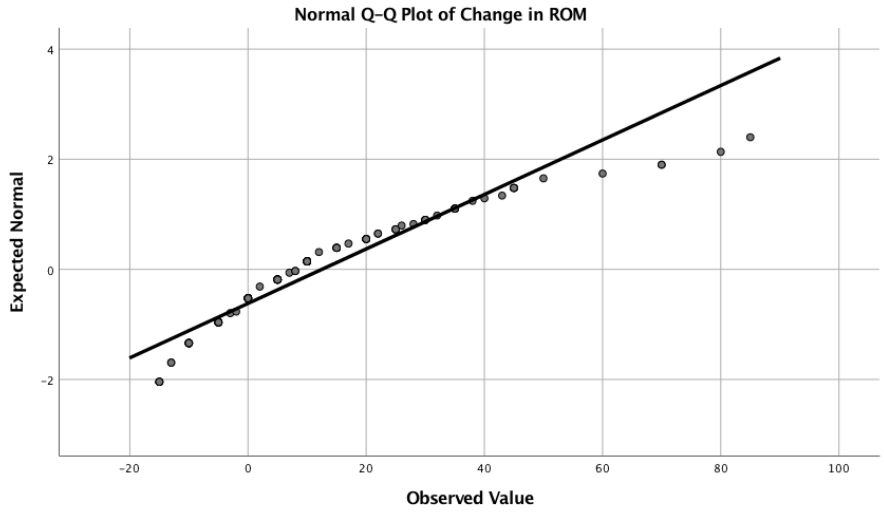

Normal Q–Q Plot of Time since RTKA
Expected Normal
Observed Value
3
2
1
0
−1
−2
−3
0.0
2.5
5.0
7.5
10.0
12.5

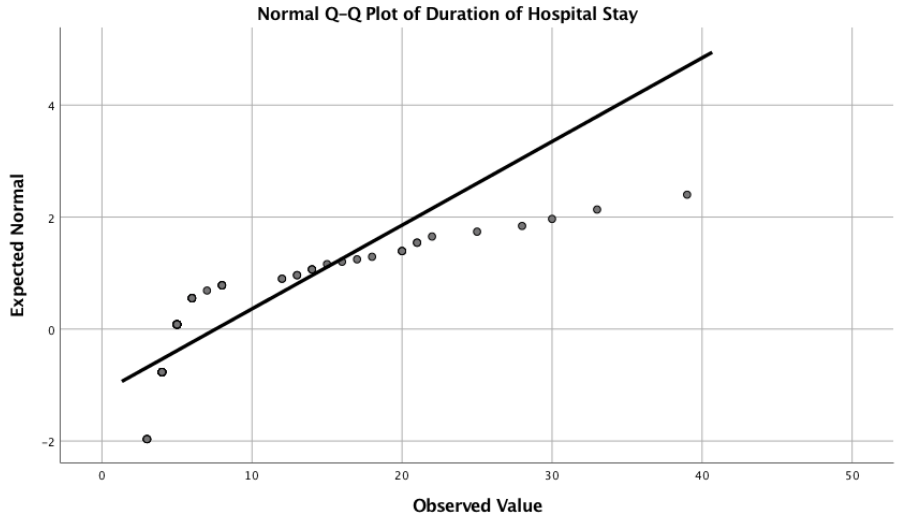

Normal Q–Q Plot of Age at time of primary TKA
Expected Normal
Observed Value
4
2
0
−2
−4
30
40
50
60
70
80
90

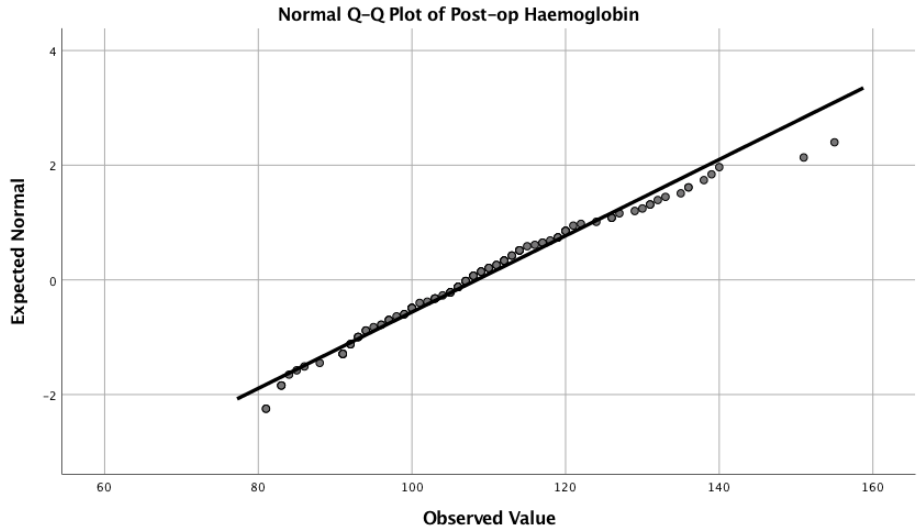

Normal Q-Q Plot of Pre RTKA ROM
Expected Normal
2
0
-2
-4
0
50
100
150
Observed Value

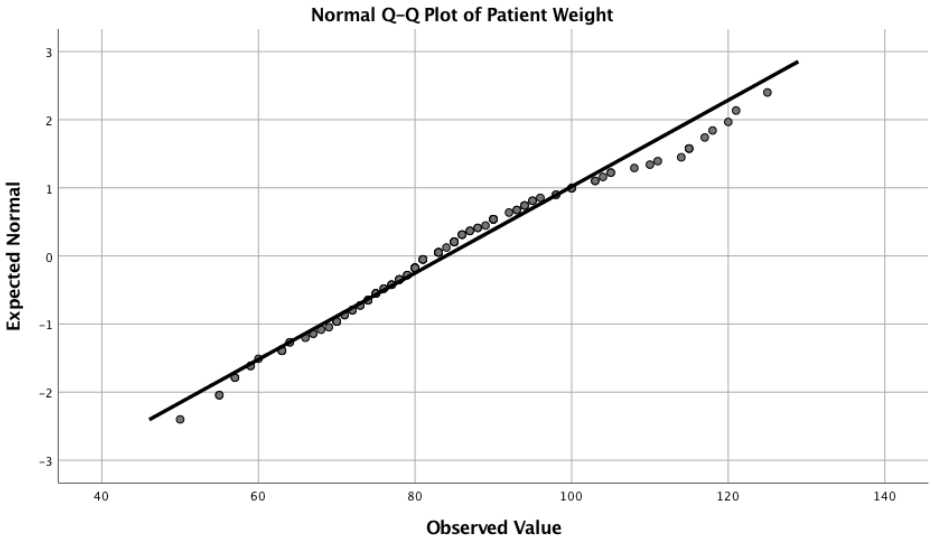

Normal Q-Q Plot of 3/12 post RTKA ROM
Expected Normal
4
2
0
-2
-4
-6
25
50
75
100
125
Observed Value

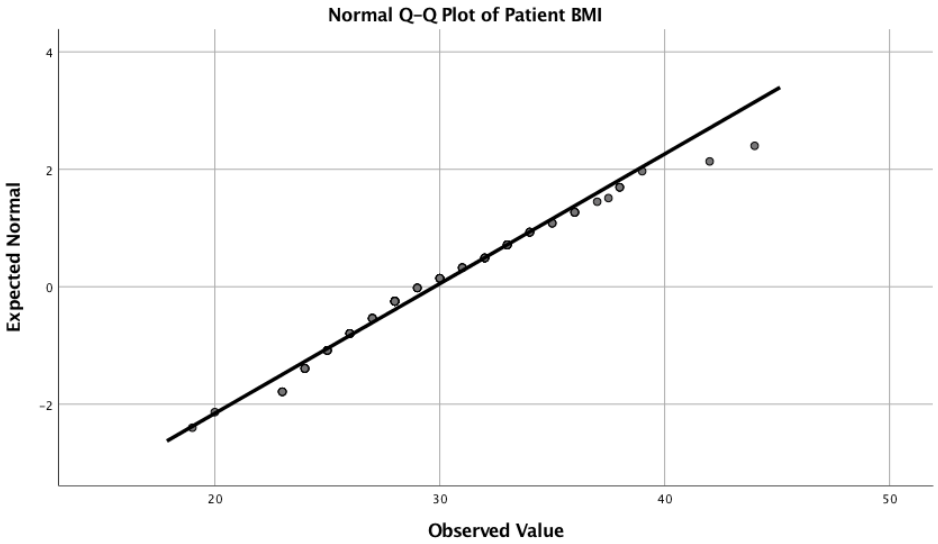

Normal Q-Q Plot of 1 Year post RTKA ROM
Expected Normal
2
0
-2
-4
-6
25
50
75
100
125
Observed Value

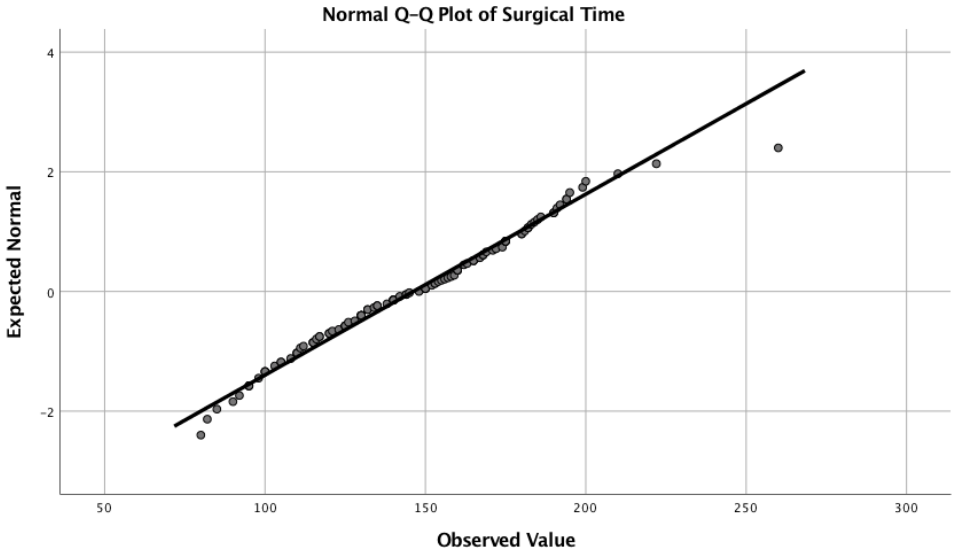

Normal Q-Q Plot of Change in ROM
Expected Normal
Observed Value
4
2
0
-2
-20
0
20
40
60
80
100


Normal Q-Q Plot of Duration of Hospital Stay
Expected Normal
Observed Value
4
2
0
-2
0
10
20
30
40
50


Normal Q-Q Plot of Post-op Haemoglobin
Expected Normal
Observed Value
4
2
0
-2
60
80
100
120
140
160


Normal Q-Q Plot of Patient Weight
Expected Normal
Observed Value
3
2
1
0
-1
-2
-3
40
60
80
100
120
140


Normal Q-Q Plot of Patient BMI
Expected Normal
Observed Value
4
2
0
-2
20
30
40
50


Normal Q-Q Plot of Surgical Time
Expected Normal
Observed Value
4
2
0
-2
50
100
150
200
250
300

Results of patient satisfaction outcomes:

RTKA Again

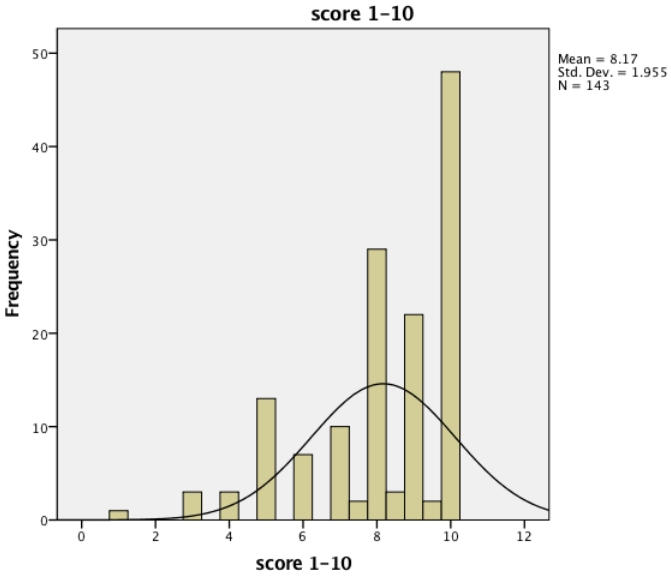
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	121	84.6	84.6	84.6
	2	12	8.4	8.4	93.0
	3	10	7.0	7.0	100.0
	Total	143	100.0	100.0	

RTKA again binary

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	121	84.6	84.6	84.6
	2	22	15.4	15.4	100.0
	Total	143	100.0	100.0	

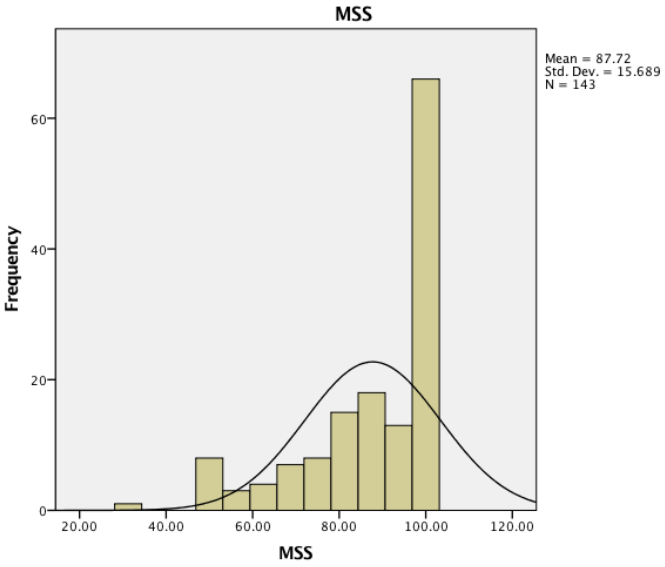
score 1-10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	.7	.7	.7
	3	3	2.1	2.1	2.8
	4	3	2.1	2.1	4.9
	5	13	9.1	9.1	14.0
	6	7	4.9	4.9	18.9
	7	10	7.0	7.0	25.9
	8	33	23.1	23.1	49.0
	9	23	16.1	16.1	65.0
	10	50	35.0	35.0	100.0
	Total	143	100.0	100.0	



MSS

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	31.25	1	.7	.7	.7
	50.00	8	5.6	5.6	6.3
	56.25	3	2.1	2.1	8.4
	62.50	4	2.8	2.8	11.2
	68.75	7	4.9	4.9	16.1
	75.00	8	5.6	5.6	21.7
	81.25	15	10.5	10.5	32.2
	87.50	18	12.6	12.6	44.8
	93.75	13	9.1	9.1	53.8
	100.00	66	46.2	46.2	100.0
	Total	143	100.0	100.0	



Comparison of assessment methods:

Hypothesis Test Summary

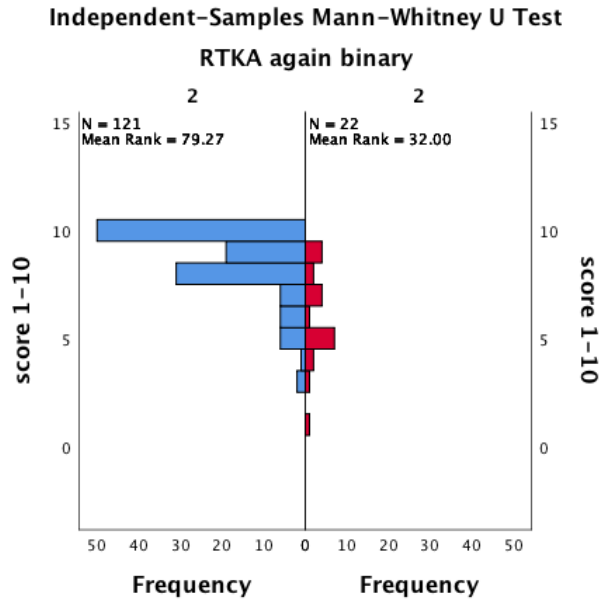
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of score 1-10 is the same across categories of RTKA again binary.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

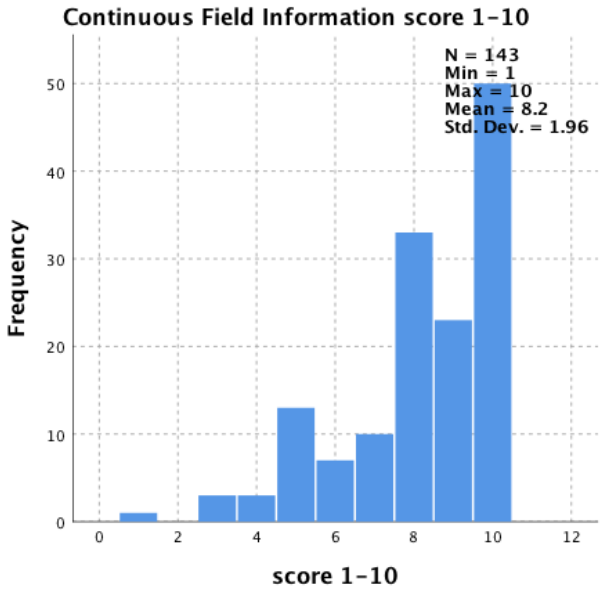
Asymptotic significances are displayed. The significance level is .050.

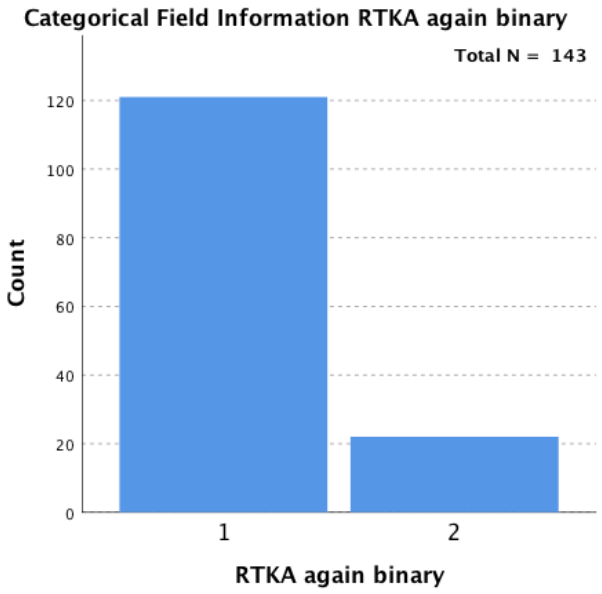
Independent-Samples Mann-Whitney U Test: score 1-10 across RTKA again binary

Independent-Samples Mann-Whitney U Test Summary

Total N	143
Mann-Whitney U	451.000
Wilcoxon W	704.000
Test Statistic	451.000
Standard Error	173.249
Standardized Test Statistic	-5.079
Asymptotic Sig.(2-sided test)	.000




Continuous Field Information score 1-10
N = 143
Min = 1
Max = 10
Mean = 8.2
Std. Dev. = 1.96
Frequency
0
10
20
30
40
50
0
2
4
6
8
10
12
score 1-10


Categorical Field Information RTKA again binary
Total N = 143
Count
0
20
40
60
80
100
120
1
2
RTKA again binary

Hypothesis Test Summary

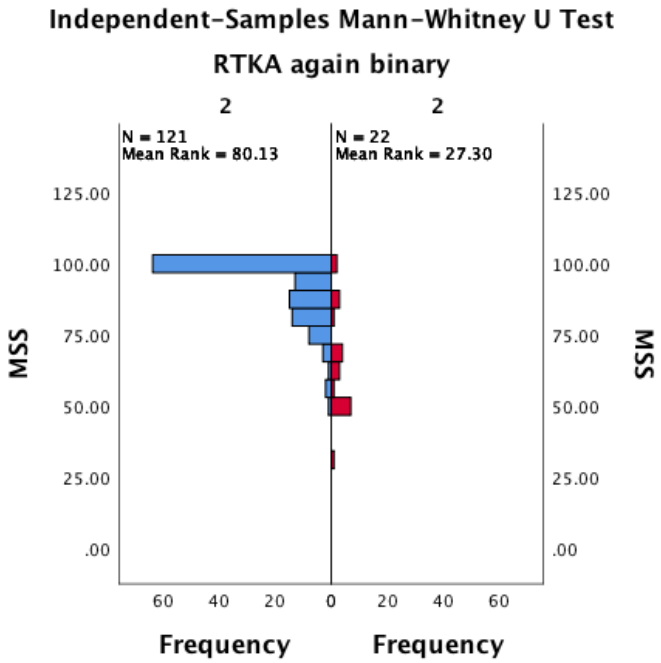
	Null Hypothesis	Test	Sig.	Decision
1	The distribution of MSS is the same across categories of RTKA again binary.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

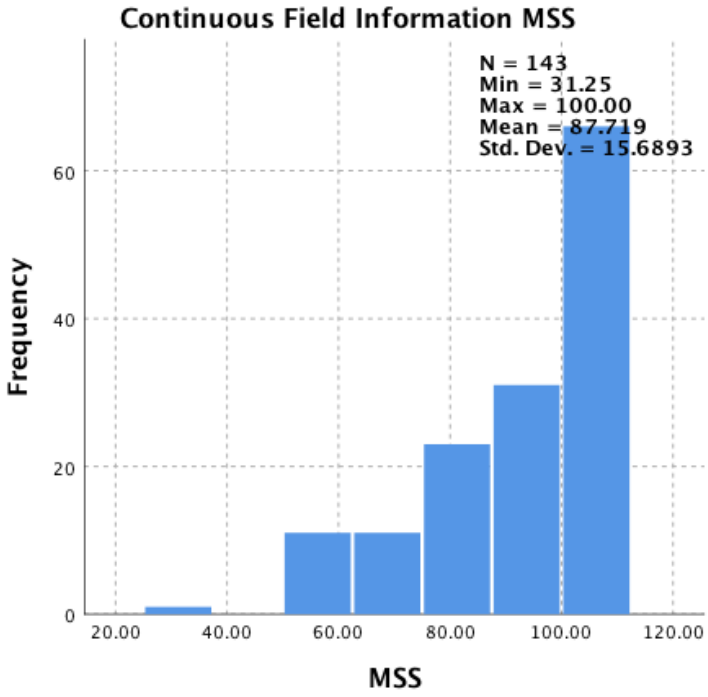
Asymptotic significances are displayed. The significance level is .050.

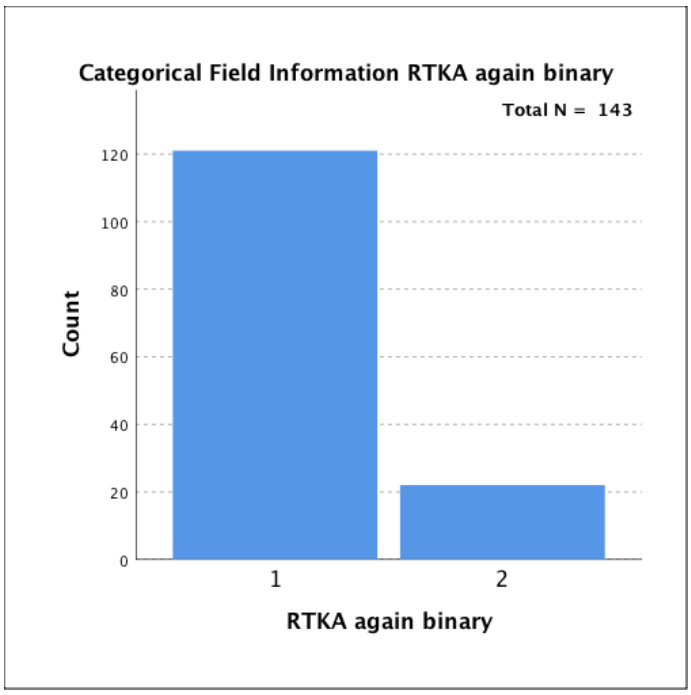
Independent-Samples Mann-Whitney U Test: MSS across RTKA again binary

Independent-Samples Mann-Whitney U Test Summary

Total N	143
Mann-Whitney U	347.500
Wilcoxon W	600.500
Test Statistic	347.500
Standard Error	169.305
Standardized Test Statistic	-5.809
Asymptotic Sig.(2-sided test)	.000


Independent-Samples Mann-Whitney U Test
RTKA again binary
2
2
N = 121
Mean Rank = 80.13
N = 22
Mean Rank = 27.30
125.00
100.00
75.00
50.00
25.00
.00
MSS
60
40
20
0
20
40
60
Frequency
Frequency


Continuous Field Information MSS
N = 143
Min = 31.25
Max = 100.00
Mean = 87.719
Std. Dev. = 15.6893
Frequency
60
40
20
0
20.00
40.00
60.00
80.00
100.00
120.00
MSS



Correlations

			score 1-10	MSS
Spearman's rho	score 1-10	Correlation Coefficient	1.000	.740**
		Sig. (2-tailed)	.	.000
		N	143	143
	MSS	Correlation Coefficient	.740**	1.000
		Sig. (2-tailed)	.000	.
		N	143	143

**. Correlation is significant at the 0.01 level (2-tailed).

Function contributing to satisfaction:

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
OKS	143	39.25	7.434	14	48
RTKA again binary	143	1.15	.362	1	2

Mann-Whitney Test

Ranks

	RTKA again binary	N	Mean Rank	Sum of Ranks
OKS	1	121	79.48	9617.00
	2	22	30.86	679.00
	Total	143		

Test Statistics[a]

	OKS
Mann-Whitney U	426.000
Wilcoxon W	679.000
Z	-5.076
Asymp. Sig. (2-tailed)	.000

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pre RTKA ROM	140	100.24	24.347	5	145
RTKA again binary	143	1.15	.362	1	2

Mann-Whitney Test

Ranks

	RTKA again binary	N	Mean Rank	Sum of Ranks
Pre RTKA ROM	1	119	75.14	8941.50
	2	21	44.21	928.50
	Total	140		

Test Statistics[a]

	Pre RTKA ROM
Mann-Whitney U	697.500
Wilcoxon W	928.500
Z	-3.235
Asymp. Sig. (2-tailed)	.001

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
1 Year post RTKA ROM	132	112.37	14.949	35	135
RTKA again binary	143	1.15	.362	1	2

Mann-Whitney Test

Ranks

	RTKA again binary	N	Mean Rank	Sum of Ranks
1 Year post RTKA ROM	1	110	69.55	7650.50
	2	22	51.25	1127.50
	Total	132		

Test Statistics[a]

	1 Year post RTKA ROM
Mann-Whitney U	874.500
Wilcoxon W	1127.500
Z	-2.069
Asymp. Sig. (2-tailed)	.039

a. Grouping Variable: RTKA again binary

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Change in ROM	131	12.28	20.413	-35	85
RTKA again binary	143	1.15	.362	1	2

Mann-Whitney Test

Ranks

	RTKA again binary	N	Mean Rank	Sum of Ranks
Change in ROM	1	110	62.39	6862.50
	2	21	84.93	1783.50
	Total	131		

Test Statistics[a]

	Change in ROM
Mann-Whitney U	757.500
Wilcoxon W	6862.500
Z	-2.502
Asymp. Sig. (2-tailed)	.012

a. Grouping Variable: RTKA again binary

Correlations

			OKS	score 1-10
Spearman's rho	OKS	Correlation Coefficient	1.000	.566**
		Sig. (2-tailed)	.	.000
		N	143	143
	score 1-10	Correlation Coefficient	.566**	1.000
		Sig. (2-tailed)	.000	.
		N	143	143

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			OKS	MSS
Spearman's rho	OKS	Correlation Coefficient	1.000	.729**
		Sig. (2-tailed)	.	.000
		N	143	143
	MSS	Correlation Coefficient	.729**	1.000
		Sig. (2-tailed)	.000	.
		N	143	143

**. Correlation is significant at the 0.01 level (2-tailed).

Assessment of predictor variables on satisfaction outcome:

Binomial logistical regression analysis was utilised to identify factors which contributed to satisfaction in this patient cohort.

The dependent variable was patient satisfaction, defined by patient response to “Would you have your RTKA again?”.

All independent variables which were considered potential impacting factors on satisfaction were assessed, including:

Patient characteristics:
Gender (Male = 1, Female = 2)
Patient age (years)
Age at time of RTKA operation (years)

Pre-operative assessment:
Patient weight (kgs)
Patient BMI
Primary TKA Cause of Failure (1 = Infection, 2 = Loosening / lysis, 3 = Stiffness, 4 = Pain, 5 = PFJ pain, 6 = Instability, 7 = Other, 8 = progression of disease in UKA)
Pre RTKA ROM total (degrees)

Intraoperative assessment:
Prosthesis type (CR = 1, PS = 2, TC3 = 3, Hinge = 4)
Surgical time (minutes)

Perioperative assessment:
Blood transfusion required post-operatively (No = 0, Yes =1)
Duration of hospital stay total (days)

Post-operative outcomes assessment:
Oxford Knee Score (OKS)
3/12 (3 months) post RTKA ROM total (degrees)
1 year post RTKA ROM total (degrees)
Change in ROM (1 year postoperative minus pre-operative)

RTKA survivorship / postoperative complication assessment:
Readmission within 90 days for RTKA related cause (No = 0, Yes = 1)
Post-operative complication (No = 0, Yes = 1)

Variables

			Score	df	Sig.
Step 0	Variables	Gender(1)	.190	1	.663
		Patient Age	.014	1	.907
		Time since RTKA	1.110	1	.292
		Pre RTKA ROM	16.317	1	.000
		3/12 post RTKA ROM	4.592	1	.032
		1 Year post RTKA ROM	5.347	1	.021
		Change in ROM	10.415	1	.001
		Readmission within 3/12(1)	.431	1	.511
		Post op Complication(1)	.150	1	.698
		Duration of Hospital Stay	1.970	1	.160
		Blood Transfusion Required(1)	.451	1	.502
		Patient Weight	2.713	1	.100
		Patient BMI	2.055	1	.152
		Surgical Time	2.665	1	.103
		CR vs PS vs TC3 vs Other	9.620	3	.022
		CR vs PS vs TC3 vs Other(1)	3.534	1	.060
		CR vs PS vs TC3 vs Other(2)	.024	1	.876
		CR vs PS vs TC3 vs Other(3)	.924	1	.336
		Cause of Failure of Primary TKA	9.497	6	.147
		Cause of Failure of Primary TKA(1)	.715	1	.398
		Cause of Failure of Primary TKA(2)	1.782	1	.182
		Cause of Failure of Primary TKA(3)	.878	1	.349
		Cause of Failure of Primary TKA(4)	2.375	1	.123
		Cause of Failure of Primary TKA(5)	.425	1	.514
		Cause of Failure of Primary TKA(6)	2.093	1	.148
		OKS	36.117	1	.000

Forward stepwise LR modelling with Probability for entry 0.05, Probability for removal 0.1, CI for exp(B) of 95%, Classification cut off 0.5.

Classification Table

			Predicted		
			RTKA again binary		Percentage
	Observed		1	2	Correct
Step 0	RTKA again binary	1	99	0	100.0
		2	21	0	.0
	Overall Percentage				82.5

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-1.551	.240	41.655	1	.000	.212

Block 1: Method = Forward Stepwise (Likelihood Ratio)

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	77.635[a]	.245	.405

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Classification Table

			Predicted		
			RTKA again binary		Percentage
	Observed		1	2	Correct
Step 1	RTKA again binary	1	95	4	96.0
		2	13	8	38.1
	Overall Percentage				85.8

Variables in the Equation

								95% C.I. for EXP(B)	
		B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Step 1[a]	OKS	-.200	.043	21.478	1	.000	.818	.752	.891
	Constant	5.714	1.520	14.125	1	.000	303.181		

a. Variable(s) entered on step 1: OKS.

Forward stepwise LR modelling with Probability for entry 0.10, Probability for removal 0.1, CI for exp(B) of 95%, Classification cut off 0.5.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	77.635[a]	.245	.405
2	73.921[a]	.268	.443
3	70.015[a]	.291	.482

Classification Table[a]

			Predicted RTKA again binary		
	Observed		1	2	Percentage Correct
Step 1	RTKA again binary	1	95	4	96.0
		2	13	8	38.1
	Overall Percentage				85.8
Step 2	RTKA again binary	1	94	5	94.9
		2	14	7	33.3
	Overall Percentage				84.2
Step 3	RTKA again binary	1	96	3	97.0
		2	10	11	52.4
	Overall Percentage				89.2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	OKS	-.200	.043	21.478	1	.000	.818
	Constant	5.714	1.520	14.125	1	.000	303.181
Step 2[b]	OKS	-.215	.046	21.416	1	.000	.807
	Patient BMI	-.126	.068	3.436	1	.064	.882
	Constant	9.909	2.848	12.102	1	.001	20100.592
Step 3[c]	OKS	-.228	.050	20.965	1	.000	.796
	Patient BMI	-.156	.074	4.442	1	.035	.856
	Surgical Time	.018	.009	3.836	1	.050	1.018
	Constant	8.536	3.065	7.754	1	.005	5093.994

Forward stepwise variable selection using a Wald model with Probability for entry of 0.10.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	77.635[a]	.245	.405
2	73.921[a]	.268	.443
3	70.015[a]	.291	.482

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Classification Table[a]

			Predicted		
			RTKA again binary		Percentage
	Observed		1	2	Correct
Step 1	RTKA again binary	1	95	4	96.0
		2	13	8	38.1
	Overall Percentage				85.8
Step 2	RTKA again binary	1	94	5	94.9
		2	14	7	33.3
	Overall Percentage				84.2
Step 3	RTKA again binary	1	96	3	97.0
		2	10	11	52.4
	Overall Percentage				89.2

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	OKS	-.200	.043	21.478	1	.000	.818
	Constant	5.714	1.520	14.125	1	.000	303.181
Step 2[b]	OKS	-.215	.046	21.416	1	.000	.807
	Patient BMI	-.126	.068	3.436	1	.064	.882
	Constant	9.909	2.848	12.102	1	.001	20100.592
Step 3[c]	OKS	-.228	.050	20.965	1	.000	.796
	Patient BMI	-.156	.074	4.442	1	.035	.856
	Surgical Time	.018	.009	3.836	1	.050	1.018
	Constant	8.536	3.065	7.754	1	.005	5093.994

a. Variable(s) entered on step 1: OKS.
b. Variable(s) entered on step 2: Patient BMI.
c. Variable(s) entered on step 3: Surgical Time.

Backwards stepwise elimination (LR) binomial logistic regression model- parameters of 0.05 probability for entry, 0.20 probability for removal, 95% CI for exp(B), classification cut-off 0.5.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Upper
Step 14	OKS	-.228	.050	20.965	1	.000	.796	.723	.878
	Patient BMI	-.156	.074	4.442	1	.035	.856	.741	.989
	Surgical Time	.018	.009	3.836	1	.050	1.018	1.000	1.037
	Constant	8.536	3.065	7.754	1	.005	5093.994		

Block 0: Beginning Block

Classification Table[a,b]

			Predicted RTKA again binary 1	2	Percentage Correct
Step 0	Observed RTKA again binary	1	99	0	100.0
		2	21	0	.0
	Overall Percentage				82.5

a. Constant is included in the model.
b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-1.551	.240	41.655	1	.000	.212

Variables not in the Equation[a]

			Score	df	Sig.
Step 0	Variables	OKS	36.117	1	.000
		Gender(1)	.190	1	.663
		Patient Age	.014	1	.907
		Time since RTKA	1.110	1	.292
		Pre RTKA ROM	16.317	1	.000
		3/12 post RTKA ROM	4.592	1	.032
		1 Year post RTKA ROM	5.347	1	.021
		Change in ROM	10.415	1	.001
		Readmission within 3/12(1)	.431	1	.511

	Post op Complication(1)	.150	1	.698
	Duration of Hospital Stay	1.970	1	.160
	Blood Transfusion Required(1)	.451	1	.502
	Patient Weight	2.713	1	.100
	Patient BMI	2.055	1	.152
	Surgical Time	2.665	1	.103
	CR vs PS vs TC3 vs Other	9.620	3	.022
	CR vs PS vs TC3 vs Other(1)	3.534	1	.060
	CR vs PS vs TC3 vs Other(2)	.024	1	.876
	CR vs PS vs TC3 vs Other(3)	.924	1	.336
	Cause of Failure of Primary TKA	9.497	6	.147
	Cause of Failure of Primary TKA(1)	.715	1	.398
	Cause of Failure of Primary TKA(2)	1.782	1	.182
	Cause of Failure of Primary TKA(3)	.878	1	.349
	Cause of Failure of Primary TKA(4)	2.375	1	.123
	Cause of Failure of Primary TKA(5)	.425	1	.514
	Cause of Failure of Primary TKA(6)	2.093	1	.148

a. Residual Chi-Squares are not computed because of redundancies.

Block 1: Method = Backward Stepwise (Likelihood Ratio)

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	58.464	23	.000
	Block	58.464	23	.000
	Model	58.464	23	.000
Step 2[a]	Step	.000	1	.999
	Block	58.464	22	.000
	Model	58.464	17	.000
Step 3[a]	Step	-.007	1	.932
	Block	58.457	21	.000
	Model	58.457	16	.000
Step 4[a]	Step	-.022	1	.883
	Block	58.435	20	.000
	Model	58.435	15	.000
Step 5[a]	Step	-.024	1	.877
	Block	58.411	19	.000
	Model	58.411	14	.000
Step 6[a]	Step	-.046	1	.831
	Block	58.366	18	.000
	Model	58.366	13	.000
Step 7[a]	Step	-.261	1	.610
	Block	58.105	17	.000
	Model	58.105	12	.000
Step 8[a]	Step	-.338	1	.561
	Block	57.767	16	.000
	Model	57.767	11	.000
Step 9[a]	Step	-.942	1	.332
	Block	56.825	15	.000
	Model	56.825	10	.000
Step 10[a]	Step	-8.343	6	.214
	Block	48.482	9	.000
	Model	48.482	9	.000
Step 11[a]	Step	-4.131	3	.248
	Block	44.351	6	.000
	Model	44.351	6	.000
Step 12[a]	Step	-.660	1	.417
	Block	43.692	5	.000
	Model	43.692	5	.000

Step 13[a]	Step	-.765	1	.382
	Block	42.926	4	.000
	Model	42.926	4	.000

a. A negative Chi-squares value indicates that the Chi-squares value has decreased from the previous step.

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	52.830[a]	.386	.638
2	52.830[a]	.386	.638
3	52.837[a]	.386	.638
4	52.859[a]	.386	.638
5	52.883[a]	.385	.638
6	52.929[a]	.385	.637
7	53.189[a]	.384	.635
8	53.527[a]	.382	.632
9	54.469[a]	.377	.624
10	62.812[b]	.332	.550
11	66.943[c]	.309	.511
12	67.603[c]	.305	.505
13	68.368[c]	.301	.498

a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.
b. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.
c. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	5.674	8	.684
2	5.673	8	.684
3	5.614	8	.690
4	5.362	8	.718
5	1.877	8	.985
6	1.916	8	.983
7	1.540	8	.992
8	2.062	8	.979
9	1.801	8	.987
10	3.468	8	.902
11	12.386	8	.135
12	14.495	8	.070
13	11.985	8	.152

Contingency Table for Hosmer and Lemeshow Test

		RTKA again binary = 1		RTKA again binary = 2		
		Observed	Expected	Observed	Expected	Total
Step 1	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.946	0	.054	12
	4	12	11.870	0	.130	12
	5	12	11.680	0	.320	12
	6	11	11.451	1	.549	12
	7	9	10.833	3	1.167	12
	8	11	9.500	1	2.500	12
	9	7	6.184	5	5.816	12
	10	1	1.543	11	10.457	12
Step 2	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.946	0	.054	12
	4	12	11.870	0	.130	12
	5	12	11.680	0	.320	12
	6	11	11.451	1	.549	12
	7	9	10.832	3	1.168	12
	8	11	9.501	1	2.499	12
	9	7	6.185	5	5.815	12
	10	1	1.542	11	10.458	12
Step 3	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.947	0	.053	12
	4	12	11.874	0	.126	12
	5	12	11.682	0	.318	12
	6	11	11.456	1	.544	12
	7	9	10.817	3	1.183	12
	8	11	9.492	1	2.508	12
	9	7	6.176	5	5.824	12
	10	1	1.562	11	10.438	12
Step 4	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.948	0	.052	12
	4	12	11.870	0	.130	12
	5	12	11.687	0	.313	12
	6	11	11.465	1	.535	12
	7	9	10.819	3	1.181	12

	8	11	9.469	1	2.531	12
	9	6	6.183	6	5.817	12
	10	2	1.568	10	10.432	12
Step 5	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.947	0	.053	12
	4	12	11.864	0	.136	12
	5	12	11.691	0	.309	12
	6	11	11.463	1	.537	12
	7	10	10.842	2	1.158	12
	8	10	9.471	2	2.529	12
	9	6	6.137	6	5.863	12
	10	2	1.592	10	10.408	12
Step 6	1	12	12.000	0	.000	12
	2	12	11.993	0	.007	12
	3	12	11.946	0	.054	12
	4	12	11.863	0	.137	12
	5	12	11.683	0	.317	12
	6	11	11.472	1	.528	12
	7	10	10.832	2	1.168	12
	8	10	9.461	2	2.539	12
	9	6	6.181	6	5.819	12
	10	2	1.568	10	10.432	12
Step 7	1	12	12.000	0	.000	12
	2	12	11.991	0	.009	12
	3	12	11.936	0	.064	12
	4	12	11.845	0	.155	12
	5	12	11.655	0	.345	12
	6	11	11.441	1	.559	12
	7	11	10.941	1	1.059	12
	8	9	9.446	3	2.554	12
	9	7	6.158	5	5.842	12
	10	1	1.587	11	10.413	12
Step 8	1	12	12.000	0	.000	12
	2	12	11.991	0	.009	12
	3	12	11.936	0	.064	12
	4	12	11.848	0	.152	12
	5	12	11.672	0	.328	12
	6	11	11.389	1	.611	12
	7	10	10.854	2	1.146	12
	8	10	9.460	2	2.540	12

	9	7	6.299	5	5.701	12
	10	1	1.551	11	10.449	12
Step 9	1	12	12.000	0	.000	12
	2	12	11.986	0	.014	12
	3	12	11.926	0	.074	12
	4	12	11.836	0	.164	12
	5	12	11.642	0	.358	12
	6	11	11.370	1	.630	12
	7	10	10.843	2	1.157	12
	8	10	9.429	2	2.571	12
	9	6	6.303	6	5.697	12
	10	2	1.665	10	10.335	12
Step 10	1	12	11.946	0	.054	12
	2	12	11.861	0	.139	12
	3	12	11.769	0	.231	12
	4	11	11.620	1	.380	12
	5	11	11.385	1	.615	12
	6	11	11.101	1	.899	12
	7	11	10.651	1	1.349	12
	8	9	9.645	3	2.355	12
	9	9	7.279	3	4.721	12
	10	1	1.741	11	10.259	12
Step 11	1	12	11.923	0	.077	12
	2	11	11.861	1	.139	12
	3	11	11.775	1	.225	12
	4	12	11.677	0	.323	12
	5	12	11.445	0	.555	12
	6	12	11.068	0	.932	12
	7	10	10.518	2	1.482	12
	8	10	9.302	2	2.698	12
	9	8	6.783	4	5.217	12
	10	1	2.647	11	9.353	12
Step 12	1	12	11.912	0	.088	12
	2	11	11.844	1	.156	12
	3	11	11.754	1	.246	12
	4	12	11.645	0	.355	12
	5	12	11.446	0	.554	12
	6	12	11.132	0	.868	12
	7	9	10.621	3	1.379	12
	8	10	9.142	2	2.858	12
	9	9	6.795	3	5.205	12

	10	1	2.708	11	9.292	12
Step 13	1	12	11.907	0	.093	12
	2	11	11.836	1	.164	12
	3	11	11.746	1	.254	12
	4	12	11.612	0	.388	12
	5	12	11.433	0	.567	12
	6	12	11.092	0	.908	12
	7	9	10.503	3	1.497	12
	8	11	9.282	1	2.718	12
	9	7	6.913	5	5.087	12
	10	2	2.676	10	9.324	12

Classification Table[a]

			Predicted		
			RTKA again binary		Percentage
	Observed		1	2	Correct
Step 1	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 2	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 3	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 4	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 5	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 6	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 7	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 8	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 9	RTKA again binary	1	95	4	96.0
		2	7	14	66.7
	Overall Percentage				90.8
Step 10	RTKA again binary	1	95	4	96.0
		2	9	12	57.1
	Overall Percentage				89.2
Step 11		1	96	3	97.0

	RTKA again binary	2	9	12	57.1
	Overall Percentage				90.0
Step 12	RTKA again binary	1	96	3	97.0
		2	9	12	57.1
	Overall Percentage				90.0
Step 13	RTKA again binary	1	96	3	97.0
		2	9	12	57.1
	Overall Percentage				90.0

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Upper
Step 1[a]	OKS	-.339	.095	12.706	1	.000	.712	.591	.858
	Gender(1)	1.387	1.310	1.122	1	.289	4.004	.307	52.153
	Patient Age	-.014	.062	.050	1	.822	.986	.874	1.113
	Time since RTKA	.000	.227	.000	1	.999	1.000	.641	1.560
	Pre RTKA ROM	-.024	.020	1.415	1	.234	.977	.940	1.015
	3/12 post RTKA ROM	.068	.058	1.382	1	.240	1.071	.955	1.200
	1 Year post RTKA ROM	-.033	.061	.286	1	.593	.968	.858	1.091
	Readmission within 3/12(1)	20.602	25832.832	.000	1	.999	885622326.717	.000	.
	Post op Complication(1)	-.542	1.453	.139	1	.709	.582	.034	10.036
	Duration of Hospital Stay	.006	.072	.007	1	.932	1.006	.873	1.159
	Blood Transfusion Required(1)	-.223	1.483	.023	1	.880	.800	.044	14.628
	Patient Weight	-.010	.060	.028	1	.866	.990	.880	1.114
	Patient BMI	-.222	.177	1.581	1	.209	.801	.567	1.132
	Surgical Time	.015	.015	1.062	1	.303	1.015	.986	1.045
	CR vs PS vs TC3 vs Other			2.931	3	.402			
	CR vs PS vs TC3 vs Other(1)	-.849	2.868	.088	1	.767	.428	.002	118.174
	CR vs PS vs TC3 vs Other(2)	-3.061	2.931	1.091	1	.296	.047	.000	14.624
	CR vs PS vs TC3 vs Other(3)	-2.627	3.239	.658	1	.417	.072	.000	41.324
	Cause of Failure of Primary TKA			5.293	6	.507			
	Cause of Failure of Primary TKA(1)	19.360	10981.384	.000	1	.999	255761917.528	.000	.

	Cause of Failure of Primary TKA(2)	17.803	10981.384	.000	1	.999	53929963.889	.000	.
	Cause of Failure of Primary TKA(3)	.619	21685.948	.000	1	1.000	1.857	.000	.
	Cause of Failure of Primary TKA(4)	19.023	10981.384	.000	1	.999	182632239.614	.000	.
	Cause of Failure of Primary TKA(5)	17.008	10981.384	.000	1	.999	24344248.187	.000	.
	Cause of Failure of Primary TKA(6)	15.572	10981.384	.000	1	.999	5791059.554	.000	.
	Constant	-20.504	28070.022	.000	1	.999	.000		
Step 2[a]	OKS	-.339	.095	12.749	1	.000	.712	.591	.858
	Gender(1)	1.387	1.309	1.124	1	.289	4.004	.308	52.044
	Patient Age	-.014	.054	.066	1	.797	.986	.887	1.096
	Pre RTKA ROM	-.024	.019	1.489	1	.222	.977	.940	1.014
	3/12 post RTKA ROM	.068	.058	1.413	1	.235	1.071	.957	1.199
	1 Year post RTKA ROM	-.033	.061	.292	1	.589	.968	.859	1.090
	Readmission within 3/12(1)	20.598	25794.104	.000	1	.999	881918143.207	.000	.
	Post op Complication(1)	-.542	1.448	.140	1	.708	.582	.034	9.930
	Duration of Hospital Stay	.006	.071	.007	1	.931	1.006	.875	1.156
	Blood Transfusion Required(1)	-.223	1.469	.023	1	.879	.800	.045	14.241
	Patient Weight	-.010	.056	.032	1	.857	.990	.887	1.105
	Patient BMI	-.222	.173	1.650	1	.199	.801	.571	1.124
	Surgical Time	.015	.014	1.237	1	.266	1.015	.988	1.043
	CR vs PS vs TC3 vs Other			2.937	3	.401			
	CR vs PS vs TC3 vs Other(1)	-.849	2.853	.089	1	.766	.428	.002	114.756

	CR vs PS vs TC3 vs Other(2)	-3.061	2.919	1.100	1	.294	.047	.000	14.305
	CR vs PS vs TC3 vs Other(3)	-2.628	3.006	.764	1	.382	.072	.000	26.147
	Cause of Failure of Primary TKA			5.376	6	.497			
	Cause of Failure of Primary TKA(1)	19.361	10985.606	.000	1	.999	255952023.675	.000	.
	Cause of Failure of Primary TKA(2)	17.804	10985.606	.000	1	.999	53970118.359	.000	.
	Cause of Failure of Primary TKA(3)	.618	21696.905	.000	1	1.000	1.855	.000	.
	Cause of Failure of Primary TKA(4)	19.024	10985.606	.000	1	.999	182753832.753	.000	.
	Cause of Failure of Primary TKA(5)	17.009	10985.606	.000	1	.999	24371482.697	.000	.
	Cause of Failure of Primary TKA(6)	15.573	10985.606	.000	1	.999	5795731.731	.000	.
	Constant	-20.500	28036.035	.000	1	.999	.000		
Step 3[a]	OKS	-.341	.093	13.526	1	.000	.711	.593	.853
	Gender(1)	1.391	1.308	1.132	1	.287	4.019	.310	52.146
	Patient Age	-.012	.051	.059	1	.808	.988	.893	1.092
	Pre RTKA ROM	-.024	.019	1.516	1	.218	.977	.940	1.014
	3/12 post RTKA ROM	.069	.058	1.424	1	.233	1.071	.957	1.199
	1 Year post RTKA ROM	-.033	.061	.290	1	.590	.968	.859	1.090
	Readmission within 3/12(1)	20.522	25996.055	.000	1	.999	817338040.177	.000	.
	Post op Complication(1)	-.584	1.355	.186	1	.667	.558	.039	7.937
	Blood Transfusion Required(1)	-.218	1.468	.022	1	.882	.804	.045	14.287

	Patient Weight	-.011	.056	.036	1	.850	.990	.887	1.104
	Patient BMI	-.223	.172	1.681	1	.195	.800	.571	1.121
	Surgical Time	.016	.013	1.347	1	.246	1.016	.989	1.043
	CR vs PS vs TC3 vs Other			3.071	3	.381			
	CR vs PS vs TC3 vs Other(1)	-.837	2.882	.084	1	.772	.433	.002	123.046
	CR vs PS vs TC3 vs Other(2)	-3.075	2.950	1.087	1	.297	.046	.000	14.973
	CR vs PS vs TC3 vs Other(3)	-2.653	3.029	.767	1	.381	.070	.000	26.645
	Cause of Failure of Primary TKA			5.375	6	.497			
	Cause of Failure of Primary TKA(1)	19.298	11033.282	.000	1	.999	240507138.066	.000	.
	Cause of Failure of Primary TKA(2)	17.759	11033.282	.000	1	.999	51577279.115	.000	.
	Cause of Failure of Primary TKA(3)	.557	21691.745	.000	1	1.000	1.745	.000	.
	Cause of Failure of Primary TKA(4)	18.979	11033.282	.000	1	.999	174717176.653	.000	.
	Cause of Failure of Primary TKA(5)	16.936	11033.282	.000	1	.999	22649817.876	.000	.
	Cause of Failure of Primary TKA(6)	15.524	11033.282	.000	1	.999	5519917.593	.000	.
	Constant	-20.297	28240.538	.000	1	.999	.000		
Step 4[a]	OKS	-.339	.091	13.788	1	.000	.713	.596	.852
	Gender(1)	1.344	1.259	1.141	1	.285	3.836	.325	45.198
	Patient Age	-.010	.049	.043	1	.836	.990	.900	1.089
	Pre RTKA ROM	-.023	.019	1.498	1	.221	.977	.941	1.014
	3/12 post RTKA ROM	.068	.058	1.409	1	.235	1.071	.956	1.199
	1 Year post RTKA ROM	-.035	.060	.335	1	.563	.966	.860	1.086

	Readmission within 3/12(1)	20.416	26057.720	.000	1	.999	735183850.094	.000	.
	Post op Complication(1)	-.658	1.251	.277	1	.599	.518	.045	6.011
	Patient Weight	-.008	.053	.024	1	.877	.992	.893	1.101
	Patient BMI	-.229	.169	1.841	1	.175	.795	.572	1.107
	Surgical Time	.015	.013	1.331	1	.249	1.015	.989	1.042
	CR vs PS vs TC3 vs Other			3.037	3	.386			
	CR vs PS vs TC3 vs Other(1)	-.785	2.910	.073	1	.787	.456	.002	136.810
	CR vs PS vs TC3 vs Other(2)	-3.008	2.961	1.032	1	.310	.049	.000	16.374
	CR vs PS vs TC3 vs Other(3)	-2.586	3.041	.723	1	.395	.075	.000	29.185
	Cause of Failure of Primary TKA			5.370	6	.497			
	Cause of Failure of Primary TKA(1)	19.274	11049.786	.000	1	.999	234832105.897	.000	.
	Cause of Failure of Primary TKA(2)	17.745	11049.786	.000	1	.999	50859307.395	.000	.
	Cause of Failure of Primary TKA(3)	.520	21690.411	.000	1	1.000	1.682	.000	.
	Cause of Failure of Primary TKA(4)	18.974	11049.786	.000	1	.999	173894684.470	.000	.
	Cause of Failure of Primary TKA(5)	16.938	11049.786	.000	1	.999	22700941.132	.000	.
	Cause of Failure of Primary TKA(6)	15.515	11049.786	.000	1	.999	5469127.814	.000	.
	Constant	-20.413	28303.757	.000	1	.999	.000		
Step 5[a]	OKS	-.340	.091	14.071	1	.000	.712	.596	.850
	Gender(1)	1.206	.880	1.880	1	.170	3.341	.596	18.732
	Patient Age	-.010	.048	.046	1	.830	.990	.900	1.088
	Pre RTKA ROM	-.023	.019	1.496	1	.221	.977	.942	1.014

	3/12 post RTKA ROM	.068	.057	1.392	1	.238	1.070	.956	1.197
	1 Year post RTKA ROM	-.035	.059	.351	1	.554	.966	.860	1.084
	Readmission within 3/12(1)	20.599	25738.179	.000	1	.999	883119761.999	.000	.
	Post op Complication(1)	-.673	1.239	.294	1	.587	.510	.045	5.794
	Patient BMI	-.248	.118	4.442	1	.035	.781	.620	.983
	Surgical Time	.015	.012	1.404	1	.236	1.015	.991	1.039
	CR vs PS vs TC3 vs Other			3.032	3	.387			
	CR vs PS vs TC3 vs Other(1)	-.745	2.867	.068	1	.795	.475	.002	130.800
	CR vs PS vs TC3 vs Other(2)	-2.967	2.917	1.034	1	.309	.051	.000	15.659
	CR vs PS vs TC3 vs Other(3)	-2.552	3.002	.723	1	.395	.078	.000	27.972
	Cause of Failure of Primary TKA			5.682	6	.460			
	Cause of Failure of Primary TKA(1)	19.361	11026.478	.000	1	.999	256066976.815	.000	.
	Cause of Failure of Primary TKA(2)	17.786	11026.478	.000	1	.999	52994322.359	.000	.
	Cause of Failure of Primary TKA(3)	.591	21713.431	.000	1	1.000	1.806	.000	.
	Cause of Failure of Primary TKA(4)	19.027	11026.479	.000	1	.999	183453219.962	.000	.
	Cause of Failure of Primary TKA(5)	16.959	11026.479	.000	1	.999	23181601.709	.000	.
	Cause of Failure of Primary TKA(6)	15.588	11026.479	.000	1	.999	5884172.289	.000	.
	Constant	-20.415	28000.664	.000	1	.999	.000		
Step 6[a]	OKS	-.339	.090	14.196	1	.000	.712	.597	.850

	Gender(1)	1.237	.865	2.046	1	.153	3.446	.632	18.773
	Pre RTKA ROM	-.024	.018	1.723	1	.189	.976	.942	1.012
	3/12 post RTKA ROM	.067	.057	1.392	1	.238	1.070	.956	1.197
	1 Year post RTKA ROM	-.035	.059	.351	1	.553	.965	.860	1.084
	Readmission within 3/12(1)	20.311	25947.469	.000	1	.999	662451096.476	.000	.
	Post op Complication(1)	-.647	1.241	.272	1	.602	.523	.046	5.959
	Patient BMI	-.241	.111	4.674	1	.031	.786	.632	.978
	Surgical Time	.015	.012	1.608	1	.205	1.015	.992	1.039
	CR vs PS vs TC3 vs Other			3.430	3	.330			
	CR vs PS vs TC3 vs Other(1)	-.774	2.906	.071	1	.790	.461	.002	137.101
	CR vs PS vs TC3 vs Other(2)	-3.063	2.920	1.100	1	.294	.047	.000	14.310
	CR vs PS vs TC3 vs Other(3)	-2.636	3.009	.768	1	.381	.072	.000	26.079
	Cause of Failure of Primary TKA			5.711	6	.456			
	Cause of Failure of Primary TKA(1)	19.334	11044.674	.000	1	.999	249280540.180	.000	.
	Cause of Failure of Primary TKA(2)	17.712	11044.674	.000	1	.999	49244590.967	.000	.
	Cause of Failure of Primary TKA(3)	.530	21675.593	.000	1	1.000	1.699	.000	.
	Cause of Failure of Primary TKA(4)	19.002	11044.674	.000	1	.999	178813384.153	.000	.
	Cause of Failure of Primary TKA(5)	16.967	11044.674	.000	1	.999	23378870.975	.000	.
	Cause of Failure of Primary TKA(6)	15.566	11044.674	.000	1	.999	5756380.606	.000	.

	Constant	-21.070	28200.282	.000	1	.999	.000		
Step 7[a]	OKS	-.331	.086	14.642	1	.000	.719	.607	.851
	Gender(1)	1.204	.857	1.973	1	.160	3.333	.621	17.880
	Pre RTKA ROM	-.027	.018	2.245	1	.134	.974	.940	1.008
	3/12 post RTKA ROM	.065	.057	1.313	1	.252	1.067	.955	1.192
	1 Year post RTKA ROM	-.034	.059	.330	1	.566	.967	.861	1.085
	Readmission within 3/12(1)	19.805	25894.126	.000	1	.999	399146855.849	.000	.
	Patient BMI	-.235	.109	4.677	1	.031	.791	.639	.978
	Surgical Time	.015	.012	1.567	1	.211	1.015	.992	1.039
	CR vs PS vs TC3 vs Other			3.352	3	.340			
	CR vs PS vs TC3 vs Other(1)	-.642	2.982	.046	1	.829	.526	.002	181.729
	CR vs PS vs TC3 vs Other(2)	-2.901	2.976	.950	1	.330	.055	.000	18.756
	CR vs PS vs TC3 vs Other(3)	-2.443	3.051	.641	1	.423	.087	.000	34.404
	Cause of Failure of Primary TKA			5.820	6	.444			
	Cause of Failure of Primary TKA(1)	19.351	11032.329	.000	1	.999	253456635.285	.000	.
	Cause of Failure of Primary TKA(2)	17.780	11032.329	.000	1	.999	52694084.281	.000	.
	Cause of Failure of Primary TKA(3)	.503	21624.399	.000	1	1.000	1.654	.000	.
	Cause of Failure of Primary TKA(4)	18.952	11032.329	.000	1	.999	170182124.673	.000	.
	Cause of Failure of Primary TKA(5)	17.040	11032.329	.000	1	.999	25137166.502	.000	.
	Cause of Failure of Primary TKA(6)	15.803	11032.329	.000	1	.999	7294552.313	.000	.

	Constant	-21.419	28146.373	.000	1	.999	.000		
Step 8[a]	OKS	-.333	.087	14.819	1	.000	.717	.605	.849
	Gender(1)	1.299	.850	2.335	1	.126	3.665	.693	19.389
	Pre RTKA ROM	-.028	.017	2.633	1	.105	.972	.939	1.006
	3/12 post RTKA ROM	.038	.030	1.551	1	.213	1.039	.979	1.102
	Readmission within 3/12(1)	20.144	25233.690	.000	1	.999	560196039.242	.000	.
	Patient BMI	-.250	.108	5.302	1	.021	.779	.630	.964
	Surgical Time	.016	.012	1.823	1	.177	1.016	.993	1.040
	CR vs PS vs TC3 vs Other			3.600	3	.308			
	CR vs PS vs TC3 vs Other(1)	-.824	2.664	.096	1	.757	.439	.002	81.212
	CR vs PS vs TC3 vs Other(2)	-3.076	2.664	1.333	1	.248	.046	.000	8.544
	CR vs PS vs TC3 vs Other(3)	-2.679	2.742	.954	1	.329	.069	.000	14.821
	Cause of Failure of Primary TKA			5.775	6	.449			
	Cause of Failure of Primary TKA(1)	19.324	11014.158	.000	1	.999	246844866.819	.000	.
	Cause of Failure of Primary TKA(2)	17.827	11014.158	.000	1	.999	55220568.328	.000	.
	Cause of Failure of Primary TKA(3)	.416	21314.482	.000	1	1.000	1.516	.000	.
	Cause of Failure of Primary TKA(4)	18.899	11014.158	.000	1	.999	161413366.245	.000	.
	Cause of Failure of Primary TKA(5)	17.084	11014.158	.000	1	.999	26281256.087	.000	.
	Cause of Failure of Primary TKA(6)	15.571	11014.158	.000	1	.999	5787634.552	.000	.
	Constant	-21.959	27532.722	.000	1	.999	.000		

Step 9[a]	OKS	-.338	.088	14.761	1	.000	.713	.600	.847
	Gender(1)	1.434	.857	2.802	1	.094	4.197	.783	22.504
	Pre RTKA ROM	-.029	.017	2.778	1	.096	.971	.939	1.005
	3/12 post RTKA ROM	.045	.030	2.285	1	.131	1.046	.987	1.109
	Patient BMI	-.248	.109	5.160	1	.023	.780	.630	.967
	Surgical Time	.019	.011	2.855	1	.091	1.019	.997	1.042
	CR vs PS vs TC3 vs Other			4.251	3	.236			
	CR vs PS vs TC3 vs Other(1)	-.985	2.617	.142	1	.707	.374	.002	63.117
	CR vs PS vs TC3 vs Other(2)	-3.406	2.615	1.696	1	.193	.033	.000	5.584
	CR vs PS vs TC3 vs Other(3)	-2.954	2.699	1.198	1	.274	.052	.000	10.337
	Cause of Failure of Primary TKA			5.442	6	.488			
	Cause of Failure of Primary TKA(1)	19.116	11017.000	.000	1	.999	200479418.406	.000	.
	Cause of Failure of Primary TKA(2)	17.809	11017.000	.000	1	.999	54269739.840	.000	.
	Cause of Failure of Primary TKA(3)	.235	21192.558	.000	1	1.000	1.265	.000	.
	Cause of Failure of Primary TKA(4)	18.792	11017.000	.000	1	.999	145033770.797	.000	.
	Cause of Failure of Primary TKA(5)	17.122	11017.000	.000	1	.999	27298375.504	.000	.
	Cause of Failure of Primary TKA(6)	15.613	11017.000	.000	1	.999	6032623.155	.000	.
	Constant	-2.633	11017.001	.000	1	1.000	.072		
Step 10[a]	OKS	-.286	.072	15.865	1	.000	.751	.652	.865
	Gender(1)	1.102	.787	1.960	1	.161	3.011	.644	14.087
	Pre RTKA ROM	-.026	.016	2.573	1	.109	.974	.944	1.006

	3/12 post RTKA ROM	.034	.028	1.482	1	.223	1.034	.980	1.092
	Patient BMI	-.209	.093	5.074	1	.024	.812	.677	.973
	Surgical Time	.024	.011	4.468	1	.035	1.024	1.002	1.046
	CR vs PS vs TC3 vs Other			3.670	3	.299			
	CR vs PS vs TC3 vs Other(1)	-.991	2.911	.116	1	.734	.371	.001	111.573
	CR vs PS vs TC3 vs Other(2)	-3.073	2.921	1.107	1	.293	.046	.000	14.181
	CR vs PS vs TC3 vs Other(3)	-2.361	2.994	.622	1	.430	.094	.000	33.353
	Constant	12.261	4.856	6.375	1	.012	211358.444		
Step 11[a]	OKS	-.236	.057	16.860	1	.000	.790	.706	.884
	Gender(1)	.665	.683	.948	1	.330	1.945	.510	7.426
	Pre RTKA ROM	-.017	.014	1.399	1	.237	.983	.956	1.011
	3/12 post RTKA ROM	.017	.022	.653	1	.419	1.018	.975	1.062
	Patient BMI	-.168	.081	4.309	1	.038	.846	.722	.991
	Surgical Time	.020	.010	4.053	1	.044	1.020	1.001	1.039
	Constant	8.403	3.343	6.320	1	.012	4460.951		
Step 12[a]	OKS	-.231	.056	17.234	1	.000	.794	.712	.885
	Gender(1)	.725	.683	1.127	1	.288	2.065	.541	7.879
	Pre RTKA ROM	-.010	.011	.779	1	.378	.990	.968	1.012
	Patient BMI	-.152	.076	4.021	1	.045	.859	.741	.997
	Surgical Time	.018	.010	3.673	1	.055	1.018	1.000	1.038
	Constant	9.050	3.155	8.226	1	.004	8520.174		
Step 13[a]	OKS	-.245	.053	21.380	1	.000	.782	.705	.868
	Gender(1)	.836	.670	1.559	1	.212	2.308	.621	8.574
	Patient BMI	-.162	.075	4.659	1	.031	.850	.734	.985
	Surgical Time	.019	.010	3.789	1	.052	1.019	1.000	1.038
	Constant	8.839	3.172	7.767	1	.005	6900.328		

a. The cut value is .500

a. Variable(s) entered on step 1: OKS, Gender, Patient Age , Time since RTKA, Pre RTKA ROM , 3/12 post RTKA ROM, 1 Year post RTKA ROM, Readmission within 3/12, Post op Complication, Duration of Hospital Stay, Blood Transfusion Required, Patient Weight, Patient BMI, Surgical Time, CR vs PS vs TC3 vs Other, Cause of Failure of Primary TKA.

Model if Term Removed

Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 1	OKS	-38.899	24.968	1	.000
	Gender	-27.019	1.208	1	.272
	Patient Age	-26.440	.051	1	.822
	Time since RTKA	-26.415	.000	1	.999
	Pre RTKA ROM	-27.187	1.545	1	.214
	3/12 post RTKA ROM	-27.160	1.490	1	.222
	1 Year post RTKA ROM	-26.561	.292	1	.589
	Readmission within 3/12	-26.783	.736	1	.391
	Post op Complication	-26.481	.133	1	.716
	Duration of Hospital Stay	-26.419	.007	1	.933
	Blood Transfusion Required	-26.426	.022	1	.881
	Patient Weight	-26.429	.028	1	.866
	Patient BMI	-27.295	1.760	1	.185
	Surgical Time	-26.954	1.078	1	.299
	CR vs PS vs TC3 vs Other	-28.008	3.186	3	.364
	Cause of Failure of Primary TKA	-30.688	8.547	6	.201
Step 2	OKS	-38.959	25.088	1	.000
	Gender	-27.019	1.208	1	.272
	Patient Age	-26.448	.066	1	.797
	Pre RTKA ROM	-27.223	1.616	1	.204
	3/12 post RTKA ROM	-27.175	1.521	1	.218
	1 Year post RTKA ROM	-26.564	.298	1	.585
	Readmission within 3/12	-26.804	.779	1	.378
	Post op Complication	-26.482	.134	1	.715
	Duration of Hospital Stay	-26.419	.007	1	.932
	Blood Transfusion Required	-26.426	.023	1	.880
	Patient Weight	-26.431	.032	1	.857
	Patient BMI	-27.346	1.863	1	.172
	Surgical Time	-27.044	1.257	1	.262
	CR vs PS vs TC3 vs Other	-28.022	3.214	3	.360

	Cause of Failure of Primary TKA	-30.702	8.574	6	.199
Step 3	OKS	-39.356	25.875	1	.000
	Gender	-27.027	1.216	1	.270
	Patient Age	-26.448	.059	1	.808
	Pre RTKA ROM	-27.239	1.641	1	.200
	3/12 post RTKA ROM	-27.186	1.534	1	.216
	1 Year post RTKA ROM	-26.567	.296	1	.586
	Readmission within 3/12	-26.809	.780	1	.377
	Post op Complication	-26.508	.178	1	.673
	Blood Transfusion Required	-26.430	.022	1	.883
	Patient Weight	-26.437	.036	1	.850
	Patient BMI	-27.370	1.902	1	.168
	Surgical Time	-27.099	1.361	1	.243
	CR vs PS vs TC3 vs Other	-28.066	3.294	3	.348
	Cause of Failure of Primary TKA	-30.717	8.597	6	.198
Step 4	OKS	-39.956	27.053	1	.000
	Gender	-27.029	1.200	1	.273
	Patient Age	-26.451	.043	1	.836
	Pre RTKA ROM	-27.239	1.619	1	.203
	3/12 post RTKA ROM	-27.189	1.518	1	.218
	1 Year post RTKA ROM	-26.601	.342	1	.559
	Readmission within 3/12	-26.809	.758	1	.384
	Post op Complication	-26.561	.264	1	.608
	Patient Weight	-26.441	.024	1	.877
	Patient BMI	-27.478	2.096	1	.148
	Surgical Time	-27.101	1.342	1	.247
	CR vs PS vs TC3 vs Other	-28.075	3.290	3	.349
	Cause of Failure of Primary TKA	-30.722	8.584	6	.198
Step 5	OKS	-40.369	27.855	1	.000
	Gender	-27.450	2.017	1	.155
	Patient Age	-26.464	.046	1	.831
	Pre RTKA ROM	-27.240	1.596	1	.206
	3/12 post RTKA ROM	-27.190	1.496	1	.221
	1 Year post RTKA ROM	-26.621	.359	1	.549
	Readmission within 3/12	-26.905	.927	1	.336
	Post op Complication	-26.582	.281	1	.596
	Patient BMI	-29.531	6.179	1	.013

	Surgical Time	-27.141	1.398	1	.237
	CR vs PS vs TC3 vs Other	-28.079	3.276	3	.351
	Cause of Failure of Primary TKA	-30.982	9.080	6	.169
Step 6	OKS	-40.373	27.816	1	.000
	Gender	-27.584	2.240	1	.134
	Pre RTKA ROM	-27.397	1.865	1	.172
	3/12 post RTKA ROM	-27.213	1.497	1	.221
	1 Year post RTKA ROM	-26.644	.360	1	.548
	Readmission within 3/12	-26.916	.903	1	.342
	Post op Complication	-26.595	.261	1	.610
	Patient BMI	-29.585	6.241	1	.012
	Surgical Time	-27.277	1.624	1	.202
	CR vs PS vs TC3 vs Other	-28.355	3.781	3	.286
	Cause of Failure of Primary TKA	-30.993	9.058	6	.170
Step 7	OKS	-40.406	27.622	1	.000
	Gender	-27.671	2.153	1	.142
	Pre RTKA ROM	-27.832	2.474	1	.116
	3/12 post RTKA ROM	-27.298	1.406	1	.236
	1 Year post RTKA ROM	-26.764	.338	1	.561
	Readmission within 3/12	-26.948	.706	1	.401
	Patient BMI	-29.658	6.126	1	.013
	Surgical Time	-27.387	1.585	1	.208
	CR vs PS vs TC3 vs Other	-28.427	3.664	3	.300
	Cause of Failure of Primary TKA	-30.996	8.802	6	.185
Step 8	OKS	-40.495	27.462	1	.000
	Gender	-28.050	2.572	1	.109
	Pre RTKA ROM	-28.234	2.940	1	.086
	3/12 post RTKA ROM	-27.600	1.674	1	.196
	Readmission within 3/12	-27.235	.942	1	.332
	Patient BMI	-30.209	6.890	1	.009
	Surgical Time	-27.695	1.863	1	.172
	CR vs PS vs TC3 vs Other	-28.770	4.014	3	.260
	Cause of Failure of Primary TKA	-31.285	9.043	6	.171
Step 9	OKS	-41.025	27.580	1	.000
	Gender	-28.790	3.112	1	.078
	Pre RTKA ROM	-28.782	3.095	1	.079
	3/12 post RTKA ROM	-28.497	2.526	1	.112

	Patient BMI	-30.579	6.689	1	.010
	Surgical Time	-28.714	2.959	1	.085
	CR vs PS vs TC3 vs Other	-29.648	4.826	3	.185
	Cause of Failure of Primary TKA	-31.406	8.343	6	.214
Step 10	OKS	-44.796	26.779	1	.000
	Gender	-32.459	2.105	1	.147
	Pre RTKA ROM	-32.762	2.711	1	.100
	3/12 post RTKA ROM	-32.197	1.582	1	.209
	Patient BMI	-34.511	6.209	1	.013
	Surgical Time	-33.721	4.630	1	.031
	CR vs PS vs TC3 vs Other	-33.472	4.131	3	.248
Step 11	OKS	-46.335	25.727	1	.000
	Gender	-33.962	.981	1	.322
	Pre RTKA ROM	-34.175	1.407	1	.236
	3/12 post RTKA ROM	-33.801	.660	1	.417
	Patient BMI	-35.965	4.987	1	.026
	Surgical Time	-35.569	4.194	1	.041
Step 12	OKS	-46.584	25.565	1	.000
	Gender	-34.387	1.171	1	.279
	Pre RTKA ROM	-34.184	.765	1	.382
	Patient BMI	-36.039	4.476	1	.034
	Surgical Time	-35.677	3.752	1	.053
Step 13	OKS	-52.879	37.391	1	.000
	Gender	-35.008	1.647	1	.199
	Patient BMI	-36.840	5.313	1	.021
	Surgical Time	-36.116	3.863	1	.049

Variables not in the Equation

			Score	df	Sig.
Step 2[a]	Variables	Time since RTKA	.000	1	.999
	Overall Statistics		.000	1	.999
Step 3[b]	Variables	Time since RTKA	.000	1	.989
		Duration of Hospital Stay	.007	1	.931
	Overall Statistics		.007	2	.996
Step 4[c]	Variables	Time since RTKA	.001	1	.974
		Duration of Hospital Stay	.006	1	.936
		Blood Transfusion Required(1)	.022	1	.882

	Overall Statistics		.029	3	.999
Step 5[d]	Variables	Time since RTKA	.007	1	.933
		Duration of Hospital Stay	.009	1	.924
		Blood Transfusion Required(1)	.010	1	.920
		Patient Weight	.024	1	.877
	Overall Statistics		.053	4	1.000
Step 6[e]	Variables	Patient Age	.046	1	.830
		Time since RTKA	.029	1	.865
		Duration of Hospital Stay	.001	1	.979
		Blood Transfusion Required(1)	.001	1	.978
		Patient Weight	.027	1	.869
	Overall Statistics		.098	5	1.000
Step 7[f]	Variables	Patient Age	.026	1	.873
		Time since RTKA	.032	1	.858
		Post op Complication(1)	.275	1	.600
		Duration of Hospital Stay	.047	1	.829
		Blood Transfusion Required(1)	.041	1	.840
		Patient Weight	.045	1	.832
	Overall Statistics		.365	6	.999
Step 8[g]	Variables	Patient Age	.026	1	.872
		Time since RTKA	.016	1	.898
		1 Year post RTKA ROM	.333	1	.564
		Post op Complication(1)	.250	1	.617
		Duration of Hospital Stay	.048	1	.827
		Blood Transfusion Required(1)	.075	1	.784
		Patient Weight	.056	1	.813
	Overall Statistics		.707	7	.998
Step 9[h]	Variables	Patient Age	.048	1	.826
		Time since RTKA	.066	1	.797
		1 Year post RTKA ROM	.562	1	.454
		Readmission within 3/12(1)	.631	1	.427
		Post op Complication(1)	.025	1	.874
		Duration of Hospital Stay	.000	1	.986
		Blood Transfusion Required(1)	.002	1	.967
		Patient Weight	.296	1	.586
	Overall Statistics		1.361	8	.995

Step 10[i]	Variables	Patient Age	.000	1	.983
		Time since RTKA	.057	1	.811
		1 Year post RTKA ROM	.647	1	.421
		Readmission within 3/12(1)	.133	1	.715
		Post op Complication(1)	.000	1	.985
		Duration of Hospital Stay	.010	1	.922
		Blood Transfusion Required(1)	.029	1	.864
		Patient Weight	.564	1	.453
		Cause of Failure of Primary TKA	7.639	6	.266
		Cause of Failure of Primary TKA(1)	4.243	1	.039
		Cause of Failure of Primary TKA(2)	.002	1	.966
		Cause of Failure of Primary TKA(3)	.183	1	.669
		Cause of Failure of Primary TKA(4)	.588	1	.443
		Cause of Failure of Primary TKA(5)	.315	1	.575
		Cause of Failure of Primary TKA(6)	2.783	1	.095
	Overall Statistics		9.185	14	.819
Step 11[j]	Variables	Patient Age	.190	1	.663
		Time since RTKA	.488	1	.485
		1 Year post RTKA ROM	1.077	1	.299
		Readmission within 3/12(1)	.319	1	.572
		Post op Complication(1)	.053	1	.818
		Duration of Hospital Stay	.062	1	.803
		Blood Transfusion Required(1)	.375	1	.540
		Patient Weight	.514	1	.473
		CR vs PS vs TC3 vs Other	4.258	3	.235
		CR vs PS vs TC3 vs Other(1)	2.691	1	.101
		CR vs PS vs TC3 vs Other(2)	2.613	1	.106
		CR vs PS vs TC3 vs Other(3)	.353	1	.552

		Cause of Failure of Primary TKA	6.782	6	.341
		Cause of Failure of Primary TKA(1)	3.296	1	.069
		Cause of Failure of Primary TKA(2)	.074	1	.785
		Cause of Failure of Primary TKA(3)	.245	1	.621
		Cause of Failure of Primary TKA(4)	.373	1	.541
		Cause of Failure of Primary TKA(5)	.253	1	.615
		Cause of Failure of Primary TKA(6)	2.924	1	.087
	Overall Statistics		13.264	17	.718
Step 12[k]	Variables	Patient Age	.082	1	.774
		Time since RTKA	.556	1	.456
		3/12 post RTKA ROM	.659	1	.417
		1 Year post RTKA ROM	.031	1	.861
		Readmission within 3/12(1)	.455	1	.500
		Post op Complication(1)	.116	1	.734
		Duration of Hospital Stay	.058	1	.810
		Blood Transfusion Required(1)	.636	1	.425
		Patient Weight	.311	1	.577
		CR vs PS vs TC3 vs Other	3.301	3	.348
		CR vs PS vs TC3 vs Other(1)	2.110	1	.146
		CR vs PS vs TC3 vs Other(2)	2.482	1	.115
		CR vs PS vs TC3 vs Other(3)	.534	1	.465
		Cause of Failure of Primary TKA	6.382	6	.382
		Cause of Failure of Primary TKA(1)	3.213	1	.073
		Cause of Failure of Primary TKA(2)	.041	1	.840
		Cause of Failure of Primary TKA(3)	.189	1	.664
		Cause of Failure of Primary TKA(4)	.368	1	.544

		Cause of Failure of Primary TKA(5)	.245	1	.621
		Cause of Failure of Primary TKA(6)	2.776	1	.096
	Overall Statistics		13.470	18	.763
Step 13[l]	Variables	Patient Age	.230	1	.632
		Time since RTKA	.251	1	.616
		Pre RTKA ROM	.793	1	.373
		3/12 post RTKA ROM	.018	1	.893
		1 Year post RTKA ROM	.163	1	.687
		Readmission within 3/12(1)	.351	1	.553
		Post op Complication(1)	.001	1	.972
		Duration of Hospital Stay	.011	1	.918
		Blood Transfusion Required(1)	.354	1	.552
		Patient Weight	.348	1	.555
		CR vs PS vs TC3 vs Other	2.717	3	.437
		CR vs PS vs TC3 vs Other(1)	1.639	1	.200
		CR vs PS vs TC3 vs Other(2)	1.933	1	.164
		CR vs PS vs TC3 vs Other(3)	.305	1	.581
		Cause of Failure of Primary TKA	6.444	6	.375
		Cause of Failure of Primary TKA(1)	3.080	1	.079
		Cause of Failure of Primary TKA(2)	.104	1	.747
		Cause of Failure of Primary TKA(3)	.190	1	.663
		Cause of Failure of Primary TKA(4)	.384	1	.536
		Cause of Failure of Primary TKA(5)	.287	1	.592
		Cause of Failure of Primary TKA(6)	2.925	1	.087
	Overall Statistics		13.612	19	.806

a. Variable(s) removed on step 2: Time since RTKA.
b. Variable(s) removed on step 3: Duration of Hospital Stay.
c. Variable(s) removed on step 4: Blood Transfusion Required.
d. Variable(s) removed on step 5: Patient Weight.
e. Variable(s) removed on step 6: Patient Age .
f. Variable(s) removed on step 7: Post op Complication.
g. Variable(s) removed on step 8: 1 Year post RTKA ROM.
h. Variable(s) removed on step 9: Readmission within 3/12.
i. Variable(s) removed on step 10: Cause of Failure of Primary TKA.
j. Variable(s) removed on step 11: CR vs PS vs TC3 vs Other.
k. Variable(s) removed on step 12: 3/12 post RTKA ROM.
l. Variable(s) removed on step 13: Pre RTKA ROM .